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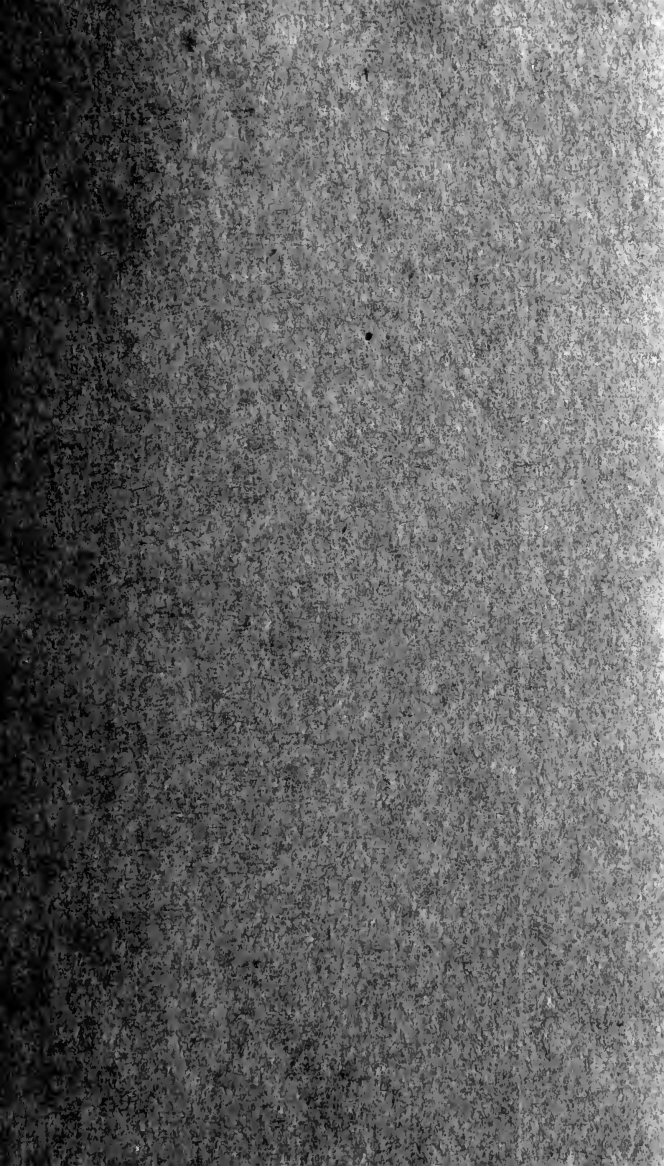
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# HARRY AND LUCY.

BY

MARIA EDGEWORTH.

COMPLETE IN THREE VOLUMES.

VOL. I.

The business of Education, in respect of knowledge, is not, as I think, to perfect a learner in all or any one of the sciences; but to give his mind that disposition and those habits that may enable him to attain any part of knowledge he shall stand in need of in the future course of his life.

LOCKE.

THE THIRD EDITION, REVISED AND CORRECTED.

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LONDON:

BALDWIN AND CRADOCK;

AND

GEORGE ROUTLEDGE, RYDER'S COURT,  
LEICESTER SQUARE.

1840.





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TO

THE CHILDREN

OF

HER FATHER'S FRIEND,

CAPTAIN BEAUFORT,

THIS BOOK IS DEDICATED

BY

MARIA EDGEWORTH.

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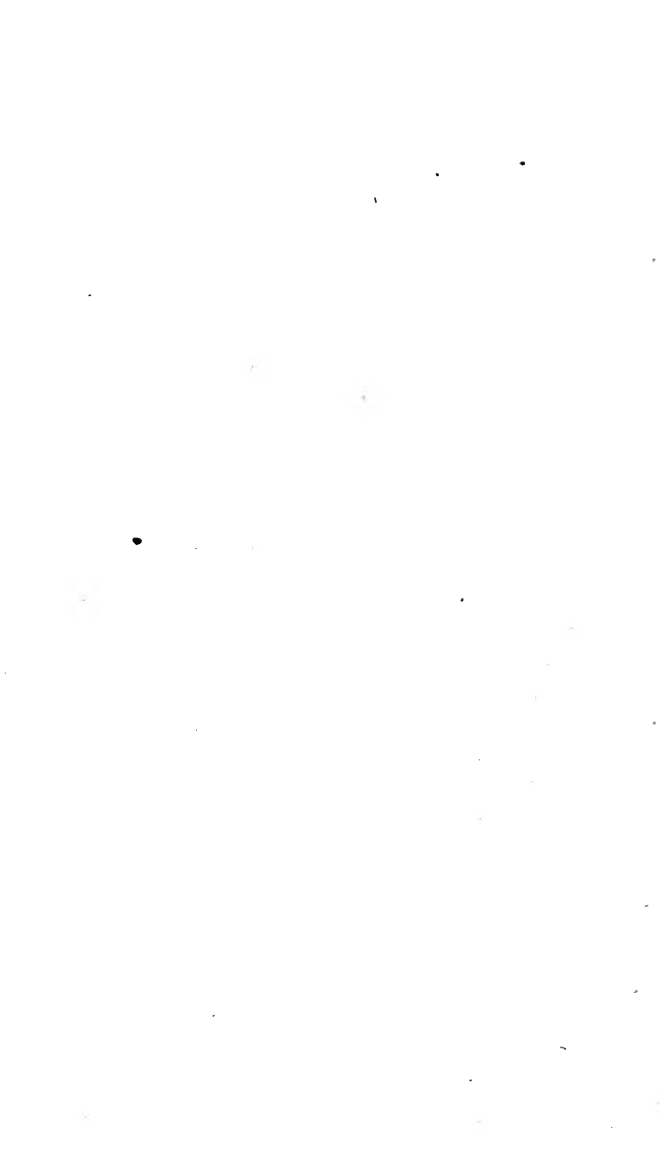


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## PREFACE;

ADDRESSED TO PARENTS.

---

THESE volumes are intended for young people from the age of ten to fourteen. They complete the series of "Early Lessons;" an humble work, from which no literary fame can be acquired, but which I have been most desirous to complete, from the belief that it will be more useful than any other in my power. I have had another motive for finishing it; one which, though it may be no concern of the public, I may be permitted to name. "Harry and Lucy" was begun by my father, above fifty years ago, for the use of his own family, and published at a time when no one of any literary character, excepting Dr. Watts

and Mrs. Barbauld, had ever condescended to write for children. That little book was, I believe, the very first attempt to give any correct elementary knowledge or taste for science in a narrative suited to the comprehension of children, and calculated to amuse and interest, as well as to instruct. Finding, from experience, that it answered the intended purpose, my father continued the book at intervals; and in the last part, published in 1813, I had the pleasure of assisting him. He then communicated many ideas for the completion of his plan, which I thought too valuable to be abandoned. I considered that a full knowledge of his views, and long habits of acquaintance with his mode of teaching, might enable me to do justice to his plan, though I was aware of the difficulty of combining ingenious with practicable illustrations, and still more sensible of the accuracy requisite for elementary scientific instruction. The want of his mind working along with my own, I knew must be in this attempt peculiarly felt; but I have been encouraged to persevere by the assistance afforded me by his and my own scientific friends. To name these kind and able friends, would gratify my vanity and

might ensure the confidence of parents; but it would, perhaps, have more the appearance of ostentation than of candour, and might leave others responsible for errors which may have escaped the most careful revisal.

I have endeavoured to pursue, in this Conclusion of Early Lessons, my father's object in their commencement—to exercise the powers of attention, observation, reasoning, and invention, rather than to teach any one science, or to make any advance beyond first principles. The essential point is to excite a thirst for knowledge, without which it is in vain to pour the full tide even to the lips. As Dr. Johnson said to Boswell, when he was describing the pains his preceptors had taken to give him learning—

“ Sir, anybody can bring a horse to the water, but who can make him drink ?”

Consistently with the sort of instruction to be conveyed, it was impossible to give as much of the amusement arising from incident and story in this book as in some others. But the varying occurrences of domestic life, the frequent changes of scene, and the different characters of the children, with all their hopes and fears in the pursuit of

their own little schemes and experiments, will, I hope, produce sufficient action to create interest, and to keep awake attention. No pernicious stimulus has been given, no deception or cajolery employed to effect our purpose. All attempts to cheat children, by the false promise that they can obtain knowledge without labour, are vain and hurtful. The gods sell everything to labour, and mortals, young or old, must pay that price. The wages of industry should, however, be rendered as certain as possible; for the pupils will exert themselves in proportion to their hopes that their efforts will be recompensed by the pleasure of success. I have taken all the precautions in my power to secure to each effort of attention its just reward.

Much that would be tiresome and insufferable to young people, if offered by preceptors in a didactic tone, will be eagerly accepted when suggested in conversation, especially in conversations between themselves. In these there is always a certain proportion of *nonsense*: an alloy which is necessary to make sense work well. Children can go on talking to one another much longer than they can bear to hear the address, however



wise or eloquent, of any grown person. Young people of good disposition learn with peculiar ease from each other, because the young teacher has not forgotten his own difficulties: knowing exactly where they lay, he sees how to remove them, or to assist another over the obstacles. The great preceptor, standing on the top of the ladder of learning, can hardly stretch his hand down to the poor urchin at the bottom, looking up to him in despair; but an intermediate companion, who is only a few steps above, can assist him with a helping hand, can show him where to put his foot safely; and now urging, now encouraging, can draw him up to any height within his own attainment.

The system of mutual instruction can be still more advantageously pursued in teaching the rudiments of science than those of literature, and may be extended even to higher branches of intellectual education. Upon this principle, in the following volumes, the young brother is employed to teach his sister what he has learned, either from his father or from books.

Harry's abilities and knowledge will perhaps appear a little above his age; but this the reader

must excuse, and attribute, as he pleases, to education, or to accident, or to natural genius. Harry will not be disliked because he is not pedantic; and he has some redeeming faults and foibles, which save him from the odium attached to a perfect character, and from the danger of being thought too good to be natural.

Lucy, on the other hand, may at times seem too childish and volatile; her respect for accuracy not being at first much greater than that of the sailor, who said, "We'll not quarrel for a handful of degrees." But these faults produce the nonsense and the action necessary to relieve the reader's attention. As to the danger and the penalties of her becoming an affected scientific lady, it is left to her mother's and her own good sense and good taste to guard against that evil. All that can be said or thought upon the subject by the other sex is comprised in the Edinburgh wit's declaration—

"I do not care how *blue* a lady's stockings may be, if her petticoats are but long enough."

My father long ago foresaw, what everybody now feels, that the taste for scientific, as well as literary knowledge, which has risen rapidly, and

has spread widely, would render it necessary to make some provision for the early instruction of youth in science, in addition to the great and successful attention paid to classical literature. In public establishments, alterations, even when felt to be requisite, must for many reasons be tardy; much, in the mean time, may be prepared by private instruction.

It has been feared by some that the general diffusion of knowledge will tend to damp the energy of genius; and that original invention will decline, in consequence of increased cultivation. This might, perhaps, be the consequence of injudicious cultivation. If the acquisition of a great quantity of learning of all kinds, or of any kind, were made the sole and ultimate object, the mind would be oppressed, and invention extinguished under the mass: but of this there is no danger if the faculties be proportionably exercised, and if the pupil be enabled to arrange, and above all to employ, his knowledge. In science, the hope of future discoveries, and the ambition to invent, are great, natural, and never-failing excitements to young and old.

That very ingenious and very mysterious phi-

losopher, Dr. Hooke, speaks somewhere in his works of an algebra by which he could determine what things are possible or impossible to perform or to invent. Without perfectly crediting or perfectly understanding this veiled prophet, we may hope and believe that the inventive power may be assisted and improved by exercise, by reasoning, and by judicious experiments. Many admirable observations on the nature and conduct of the understanding, on the causes which have prevented our advancement in knowledge, and on the habits of false reasoning, prepossessions, and prejudices, which enslave and disable our faculties, are to be found in the works of Bacon and of Hooke, of Locke, Stewart, and Playfair. These observations should not be suffered to lie dormant in books, the admiration only of the learned; nor should we be content with merely citing them occasionally, to adorn our writings, or to point our conversation. Metaphysics, after being too much in fashion, have been thrown aside too disdainfully, and their use and abuse have been confounded. Surely it would be doing good service to bring into popular form all that metaphysicians have discovered, which can be applied to

practice in education. This was early and long my father's object. The art of—teaching to invent I dare not say—but of awakening and assisting the inventive power by daily exercise and excitement, and by the application of philosophic principles to trivial occurrences, he believed might be pursued with infinite advantage to the rising generation.

I have now stated all the objects of this book: how far they have been accomplished must be left to time, and parents, and, above all, to children to decide.

MARIA EDGEWORTH.

*May 31st, 1825.*



## HARRY AND LUCY.

---

### BAROMETER.

“MAMMA, do you recollect, two years ago, when my father was explaining to us the barometer and thermometer, and when he showed us several little experiments?” said Lucy, and she sighed.

“Yes, my dear, I remember that time very well,” said her mother; “but why do you sigh?”

“Because I was very happy *then*,” said Lucy.

“And are not you happy now, my dear?”

“Yes, mamma, but not so very happy as I was then, because now I do not *go on* with Harry as I used to do.”

“How so? I hope that you have not had any quarrel with your brother?”

“Quarrel! oh no, mamma, it would be impossible to quarrel with Harry, he is so good-natured; and he is as fond of me as ever, I believe. But yet, I do not know how it is, we do not suit each other quite so well as we did. We are not so much together; I do not know all he is doing, nor go on with all he is thinking of as I used to do.”

“My dear Lucy, you and your brother have been learning different things for some time past; and as you grow older, this must be; your different employments must separate you during a great part of the day; and so much the better, you will be the more glad to be together in your hours of amusement. Do not you find this?”

“Yes, I do, mamma,” said Lucy, “but—” and after this *but* she sighed again. “But now we are not amused always in the same way. Harry has grown so excessively fond of mechanics, and of all those scientific things, which he is always learning from my uncle and papa.”

“I thought, Lucy, that you were fond of those things too?” said her mother.

“So I am, mamma; only I am not nearly so fond of them as I was formerly: I do not exactly know why; but, in the first place, I suppose, because I do not understand them now nearly so well as Harry does: he has got very far before me.”

“True,” answered her mother, “you have been learning other things, which it is more necessary for a girl to know.”

“Yes, mamma, I remember your saying just after that happy barometer time, that I thought of nothing but experiments; papa said, that must not be. Then I was not allowed to go into his room with Harry in the mornings. However, I



learned more of arithmetic, and drawing, and dancing, and music, and work."

"And you grew fond of these; so much the better," said her mother. "This does not make you less happy, does it?"

"No, no, mamma; but then came the time when Harry and I were quite separated. That long—long—long time, when you were ill, mamma, and when I was at my aunt Pierrepont's: while I was with her, I read nothing but stories and poetry, and I heard my aunt and people who were there reading plays. She used to praise me for understanding wit, and for repeating poetry. Then I grew very fond of them. But Harry is so grave always about wit, he never understands it at first; and at last he says, 'Is that all?'—As to similes, they always interrupt him."

"*They* interrupt him!" said her mother, "perhaps, Lucy, *you* interrupt him."

"Sometimes, perhaps, I do, mamma; but he always finds out that similes are not exact. This is very provoking. I wonder why he is so much fonder of exactness than I am."

"Probably because in science, which he has been learning, he finds at every step the use, the necessity of exactness. He could not go on without it in measuring or in reasoning."

"Mamma, I understand the use of exactness

in some things. In drawing in perspective, and in proportion, by a scale, as you taught me. Harry came to me the other day, and asked me to draw a cart for him; and I was glad to find that I could help him in something."

"And I dare say he will be glad to help you in his turn. You each know different things, which you can learn from one another, and in which you can be of mutual assistance. This is just as it should be between friends."

"Thank you, mamma, you make me feel happy again. I will ask Harry to bring me up to him in all he has been learning, as fast as possible, that we may go on together as we used to do, if you have no objection, mamma."

"Do so, my dear Lucy; but I warn you, that you should not expect to go fast; you must be content to go slowly, and you must submit to be inferior to your brother for some time. This may mortify you, my dear, but it cannot be avoided, you must bear it."

"Very well, mamma, I can bear it. But mother," said Lucy, hesitating a little; "there is one other thing I want to say, before I can be quite happy."

"Say it then, my dear: what-are you afraid of?—Not of me, I hope?"

"Oh! no, mamma, not afraid of you; but I am not sure that the person, who said what I

want to tell you, would like that you should know that he said it?"

"You can tell me what was said, then, without telling me from whom you heard it. Cannot you, Lucy?"

"I can, and I will," said Lucy. "Then you must know, mamma, that one day, when I was at my aunt Pierrepont's, she was telling *somebody* that papa used to teach me scientific things, along with Harry; but that, since I had come to her, I had not learned any thing of that sort. And—now it comes, mamma, the gentleman, who is not to be named, laughed."

"Well, there was no great harm in that."

"No, mamma; only that he laughed in a particular sort of way, scornfully. And he said, that it was well for me I had left off such *learning*; that I should be a much more agreeable woman without it; that ladies had nothing to do with science, or ought to have nothing to do with it. He said, that scientific ladies are always displaying what they know, or what they do not know. Those were his very words. He said, that scientific ladies were his *abhorrence*. And he looked as if he abhorred them terribly. I was very sorry at the time, that he knew papa had taught me any thing along with Harry. I was ashamed and frightened, and I thought it was all wrong. But now that I am come home I think, that it was all

right ; for I see how much papa likes that you should know the scientific things that he is busy about, and how happy it makes you ; and I want to go on again with Harry : only I wish, mamma, that all people were of the same opinion about *this*."

Her mother smiled, and said, " That can never be, my dear Lucy : you will find many people have different opinions upon this subject. But all will agree with your nameless gentleman, that when women pretend to understand what they do not, whether about science or any thing else, they are absurd and ridiculous. And if they talk even of what they understand, merely to display their knowledge, they must be troublesome and disagreeable. Therefore they should take care not to do so. They should be particularly cautious of talking on scientific subjects, because they seldom obtain accurate knowledge ; they are, therefore, likely to make mistakes, and to be either troublesome in asking questions, or ridiculous in showing ignorance and conceit."

" That is," said Lucy, " if they *set up* for being scientific ladies."

" Yes, if they do that, they must take the consequences, they will be disliked," said her mother.

" But then, mamma, I am so much afraid of being abhorred. Even if they are not conceited, will they be abhorred, mamma ?"

“Not by persons of sense, my dear,” said her mother. “As far as I can judge, I think that sensible men would be ready to assist any unaffected, unassuming woman, who really wished to inform herself, and would like her the better for being interested in their conversation, their writings, and their pursuits.”

“I hope, then, mamma, that I shall be an unaffected, unassuming woman.”

“I hope so, my dear child,” said her mother. “If your father did not hope so too, he would never teach you any more on these subjects.”

“I should be very sorry for that,” said Lucy.

“Yes, I think you would, my dear: for, even with your little experience, you feel that there is a real pleasure in going on, as you say, with your brother.”

“That I do, indeed, mamma.”

“As you grow older,” continued her mother, “you will perceive, that, by acquiring knowledge, women not only increase their power of being agreeable companions to their fathers, brothers, husbands, or friends, if they are so happy as to be connected with sensible men, but they increase their own pleasure in reading and hearing of scientific experiments and discoveries; they acquire a greater variety of means of employing themselves independently, and at home. But, above all, the acquisition of knowledge not only

enlarges but elevates the mind, by filling it with admiration and gratitude towards that bountiful Providence who has established such wise laws for the welfare and preservation of the world."

"Yes, mother," said Lucy; and, after a pause, in which she re-considered all her mother had been saying, she returned to what still a little alarmed her imagination. "But yet, mamma, I feel afraid of being *abhorred*; and if the acquiring knowledge should make me vain—there is the danger."

"There is the danger to be sure," said her mother. "But, as far as I have observed, ignorant women are as vain, and often more so, than those who are well informed; and now, when almost all are so educated that they have a taste for literature, and some acquaintance with scientific subjects, there is less danger that any should be vain, of what is no peculiar distinction."

"Oh, mother, I will take the greatest care," said Lucy; "you shall see, as I grow up; and thank you for explaining all this to me."

"Perhaps, my dear, part of what I have been saying is rather above your comprehension?"

"No, mamma; not at all. If it is not conceited to say so, I think I understand it all perfectly well; and now I know what is right and wrong, and my mind is settled; and I am happy again, and very glad that I may have the pleasure of learning again from papa; and, above

all, glad that I may *go on again* with Harry. And here he comes, mamma ; I see him from this window, coming along the path from my uncle's. Oh, mamma ! he has a great walking stick in his hand, and he is hobbling like an old man of an hundred and ten."

" I hope he has not hurt himself," said her mother, coming to the window.

" No, mamma, I believe he is only in play. There ! the old man is running as well as ever he did in his life ; and I will run and meet him."

As soon as Lucy was near enough to make her voice heard, she asked her brother why he walked with his uncle's walking stick ? as she supposed it to be.

" It is not his," said Harry, " it is mine ; my uncle has given it to me."

" Yours ! and it is quite new ; I never saw it before. How beautifully varnished ! and what a pretty head ! But why did my uncle give it to you, Harry ? It would be of use to him, and it will be of none to you," said Lucy.

" There you are mistaken ; I beg your pardon, Lucy. It will be of as much use to me as it would be to him, and of the same sort of use," said Harry.

" Same sort of use !" said Lucy ; " but of what sort ?"

" Guess," said Harry.

“ I suppose you mean in play, to act an old man, as you did just now ? ”

“ No in earnest useful,” said Harry.

“ What *can* you do with it ? ” said Lucy ; “ for you are too young to walk with it, and too old to ride upon it.”

“ Too old ! to be sure I am,” said Harry, indignantly ; “ I have not ridden upon a stick these hundred years. Guess again.”

Lucy now wanted to examine this wonderful stick more closely, in hopes of discovering what its merits might be, but Harry seemed unwilling to let it out of his hands.

“ Oh ! I know what it is. It is full of money. It is like the staff which the man had in the trial in Don Quixote, which Sancho Panza found out was full of money, because he would not let it out of his hands.”

“ I do not in the least know what you mean,” said Harry, “ for there is no money in this.”

“ Then let me look at it ; I will not run away with it. How heavy it is,” observed Lucy, “ what wood can it be made of ?—This outside seems to be mahogany, but I never felt any so heavy. It cannot be all wood ; it must be hollow, and there must be something withinside of it.”

“ Stop ! stop ! do not shake it ; do not turn it upside down ; you will spoil it,” cried Harry.

“ Ho ! ho ! then there is something withinside



of it. I have found that much out," said Lucy; "and you say, 'Do not turn it upside down,' like the words on the box of glass that came last week; 'Keep this side uppermost.' So I guess that there is glass within your stick. You smile, there is! Glass!—Then perhaps it is a spy-glass, —a telescope?—a magnifying glass? a microscope? No, none of these? What can it be? Of what use can glass be in a walking stick, Harry?"

"Of a great deal, as you will acknowledge when you find it out. Guess again," said Harry; "it is a thing that you have seen."

"But I have seen so many things," said Lucy.

"And of which you know the use," said Harry.

"But I know the use of many things! Tell me a little more," said Lucy; "what is it used for?"

"For weighing *something*," said Harry; "stay, I am not sure that it is quite fair to say it is used for weighing a *thing*, and yet it is something."

"I know now," said Lucy; "that motion you made with your hand up and down against the air, told me. The *something* that it is used for weighing is air, and it is a barometer."

"Now you have found it out," said Harry.

"And now I know what makes your stick so heavy," said Lucy. "The quicksilver—the mercury. I remember feeling the weight of mercury, when papa put into my hands two cups of the same size, one full of water, and the other full

of mercury. How stupid I was not to think of this at first, and not to guess it was a barometer!"

Harry now showed where his walking stick opened, and he showed her withinside of it a barometer and thermometer; he explained to her how the quicksilver was screwed up tight, so as to prevent it from shaking. He told her this was called a portable barometer.

"Yes, it is portable," said Lucy; "it can easily be carried from place to place. It must be convenient to travellers. But is it in any other way better than the barometer which hangs up in papa's room, or than that which stands upon three legs in my uncle's library?"

Harry said, that he was not sure that it was better for common use, to show the changes of the weather; "but this," said he, "is not merely a weather-glass, as barometers are sometimes called. This is intended for another purpose."

"What other purpose?" said Lucy.

"First, let me tell you why my uncle gave it to me," said Harry; "because he was pleased with my having taken pains, two years ago, to understand the barometer, and with my remembering it now. Then he bid me try to find out the particular use of this portable barometer."

"And did you, Harry?"

"Yes, but I was helped. My father, who was present, put me in the right road. I was very

stupid at first. My head went quite off the wrong way, but my father was very patient, and brought it back again, and set it upon the right road. Still I was very slow. My uncle thought I should never find it out. He said it was too difficult, and that my father had better tell me. But papa said he was almost sure that I should find it out myself. This encouraged me, and I tried and thought again, and my uncle left off walking up and down the room fretting. He was so good as to be patient too."

"That was kind of him," said Lucy; "I know it is very difficult to be patient with people, if they are slow in finding a thing out, when one knows it all the time. One longs to tell, or to push them on to it."

"Papa did not *push* me," said Harry, "that would have thrown me down; but he pulled, he helped me on gently, step by step, as he does so nicely; and he let me find it out at last quite by myself."

"Well, then, you can do the same for me, Harry."

"I will try," said Harry.

"Thank you. But first let me tell you all that I have been saying to mamma, and all that mamma has said to me."

She repeated it all, as well as she could, ending with, "Mamma tells me that I may *go on* with you, Harry, as we used to do; and she said she

thought that you would be so kind as to bring me up to you in all you have been learning."

"I will try," said Harry.

"I hope I shall not be very stupid," said Lucy.

"No, no, Lucy, I dare say you will not; do not begin by thinking you will, that is a very bad way; because then you go on, thinking you are afraid you will be stupid, instead of attending to what is asked and said to you. Now, Lucy, suppose you were at the bottom of a deep well."

"If I were at the bottom of a well, then I should find out **the** truth; because you know the common proverb, as Mr. Cranbourne said, that truth is at the bottom of a well."

"Nonsense," my dear Lucy, cried Harry; "now if you go to your wit, and what Mr. Cranbourne says, I cannot attempt to talk to you about the barometer."

"Well, I will be very attentive," said Lucy. "Suppose, then, I was at the bottom of a well. But should not I be drowned?" added she, in a low voice.

"Very true, I should not have said the bottom of a well, but the bottom of a deep pit," said Harry.

"Oh, that is another affair," said Lucy, "I like that better. Now, then, I am at the bottom of a deep pit."

"Now, then, which do you think would press the heaviest, the air at the bottom of this pit, or the air at the top of a high house?"

“ I think it would press heaviest at the bottom of the pit,” said Lucy.

“ Why ?” asked Harry.

“ Oh ! my dear, such an easy question,” said Lucy.

“ Well, answer it at any rate,” said Harry.

“ Because, in the bottom of the pit, the air in the pit is added to the air that is above the pit, and also you must add all the air that reaches to the top of the house.”

“ I believe you understand it. Suppose you took this barometer to the bottom of the pit, do you think that the mercury would rise or fall ? My dear Lucy pray think before you answer.”

Lucy thought, and answered : “ I think it would rise at the bottom of the pit.”

“ Right ; now if you took it to the top of a high house, would it rise or fall ?”

“ I think it would fall,” replied Lucy.

“ Why ?” said Harry.

“ Because then there would be less weight pressing upon the quicksilver in the cup, and therefore less quicksilver would be pressed up into the tube.”

“ Very well indeed, Lucy ; I see you remember all papa taught us about the barometer. Now suppose the pit was sixty feet deep, and that the house was forty feet high. Forty and sixty make a hundred, you know.”

“ To be sure,” said Lucy. “ Well ?”

“ Well,” said Harry, “ I must go slowly. Suppose that you observe exactly how much the quicksilver falls, when you take it from the bottom of the pit to the top of the house, you would have a measure by which you could judge of the whole height and depth.”

“ I see I should,” said Lucy; “ I see! I see the use of your barometer, and it is very useful.”

“ But you do not see all yet,” said Harry. “ By marking this you would not only know how much the quicksilver falls in that hundred feet; but by dividing it, and making a scale, you might know the same thing afterwards, in any number of feet, in any height to which you might take the barometer; and by this you would have an easy way of measuring the height of mountains.”

“ Very ingenious! very convenient!” said Lucy. “ Now I understand the use of your portable barometer perfectly.”

“ Not perfectly,” said Harry. “ There is a great deal more to be learned about heat at different heights, and rarefaction of the air. But I will not puzzle you with that, especially as I am not clear about it yet myself. But this is the general notion, which papa says is quite enough at first.”

“ Quite enough for me,” said Lucy. “ Thank you, Harry, for telling me no more.”

## PORTABLE BAROMETER.

“ I WISH ! oh how I wish ! ” cried Harry, “ that we had a mountain to measure with my portable barometer ! ”

“ But, ” said Lucy, “ a mountain will not come to you, for wishing for it, any more than to Mahomet. ”

“ Mahomet ! ” repeated Harry. “ What do you mean ? ”

“ Do not you know, Harry, the common saying, Since the mountain will not come to Mahomet, Mahomet must go to the mountain ? You were by, Harry, when I read this in our Universal History to mamma. Do not you remember it ? ”

“ No, I forget it. How much better you, Lucy, remember some sorts of things than I do. ”

“ And how much worse I understand other sorts of things than you do ! therefore, as mamma says, we can help one another, and then in time we shall know twice as much between us. My dear Harry, how convenient that will be, and how happy we shall be. ”

“ Very happy ; but we cannot be always together, ” said Harry, “ so we must learn to re-

member what we want for ourselves, or it will be rather inconvenient, when we are separate."

"We shall not be separated for a great while," said Lucy. "Papa said yesterday to mamma, I heard him, that you are not to go to school yet."

"I am very glad of that," said Harry, "for I shall be so happy going on at home, learning from my father, and with you Lucy! But, my dear, to go back to Mahomet, for I do not like to let that go, without in the least understanding what it means."

"Never mind; only a bit of wit," said Lucy.

"But cannot you explain it to me?" said Harry.

"No, it is so easy, that if you do not see it at first, I cannot make it plainer," said Lucy.

"Do try," said Harry.

"It means only that Mahomet was foolish for commanding the mountain, in a braggadocio way, to come to him; and when all the people standing by expected, perhaps, that the mountain should obey him, and come at his bidding, and when it did not stir, he came off in a shabby way, by saying, that since the mountain did not come to him, he must go to the mountain."

"Is that all!" said Harry; "but you told me it was a common saying."

"Yes, afterwards it came to be a common saying, whenever a person proposes something,



which seems fine and grand, and which they cannot really do, and when they come off with doing something common and easy, then comes the saying about Mahomet and the mountain."

"Thank you," said Harry, in a tone as if he had said, "Thank you for nothing." "But still I do not understand how this applied to my wishing for a mountain to measure with my portable barometer."

"Oh! my dear Harry, do not be so grave about it," said Lucy.

"I only look grave, because I am trying to understand," said Harry, "how the story applied."

"I suppose it did not *apply*, as you call it," said Lucy, after considering for a few moments. "But do not let us talk any more of it."

"Only tell me how it came into your head?" said Harry.

"I cannot tell," said Lucy: "when you said something about wishing the mountain would come to you—"

"No, no," interrupted Harry, "that was not what I said exactly."

"Well, never mind *exactly*, about such a thing as this, my dear Harry," said Lucy; "I only know, that whatever it was that you said, the sound of the words about mountain, brought the mountain and Mahomet into my head."

"The sound of the words," said Harry; "so,

after all, the words only came jingling into your head from the sound, and had nothing to do with the business; and I have been all this while trying to make sense of nonsense."

"I told you it was nonsense at first," said Lucy.

"You told me it was wit," said Harry.

"Well, my dear, if one tries to explain wit, it often turns into nonsense."

"Then what great good is there in wit?"

"If you understand it at first, it is very diverting; that is good," said Lucy.

"But if I cannot understand it at first," said Harry.

"Why, then, I cannot help it," said Lucy,

"That is rather provoking," said Harry.

"More provoking for me," said Lucy, "this time. I have been trying and trying to explain; but in explaining, the wit is lost, the pleasure at least is all gone."

"But that was not my fault," said Harry

"Yes, but it was, my dear, for not understanding it at first."

"That is the same thing you said before, my dear Lucy."

"Because it is the truth, my dear, and I have nothing else to say, Harry."

"And I have only to make the same answer I made before, Lucy; that if I cannot understand it I cannot."

“And I come round again to ‘I cannot help it, Harry.’”

“That is arguing in a circle, as papa says,” observed Harry.

“I do not know what is meant by arguing in a circle,” said Lucy; “I suppose it is something in Euclid.”

“No, my dear, Euclid never argues *in* a circle, he only argues *about* a circle or circles.”

“*In* and *about*,” said Lucy; “Oh let us say no more about it. I hate saying so much about one thing.”

“I like to stick to one thing, till I understand it,” said Harry.

“But when you can’t!” said Lucy; “you really are so slow, Harry, about wit.”

“Perhaps I am a little slow,” said Harry; “but recollect, Lucy, that you acknowledged yourself, at last, that the story did not apply, so how could I understand it?”

“Well, I acknowledge,” said Lucy; “but that excuse will do only for this once.”

“I dare say I shall find another next time,” said Harry. “But now look, Lucy, at those two men carrying that long ladder across the lawn. What are they going to do with it, I want to know?”

They were carrying it to a church in the village, the steeple of which wanted some repair;

his father followed the men, and Harry asked if Lucy and he might go with him. His father gave him leave, and Harry took his portable barometer with him, saying, that he thought he could try it at the top of the church.

In the church there were stairs which led up to the gallery, but there was no way of going up to the top of the tower, but by means of a ladder. The men fixed it steadily, and Harry's father went up. Harry wanted to follow, but his father said he must not come yet, because he had not time to think of him till their business was finished.

"My dear Harry," said Lucy, "I think it is very dangerous; you will never be able to go to such a height. I am almost afraid to look at papa going up, it makes my head giddy."

And when his father called him, she held the flap of his coat, and said, "Indeed, Harry, you had better give it up."

"Give it up!" no, that he would not.

He began to run up the ladder with the barometer in his hand. But his father called to him and bid him "stop," and ordered him to give the barometer to one of the masons, who was behind him, whom he requested to carry it for him, and to follow him up the ladder.

"Oh! papa, I am used, you know, to mounting ladders, and I am safe without any body to take care of me."

“Do as you are desired, or you shall not come up at all,” said his father.

Harry obeyed; and when he got high up on the ladder, he felt that his father was right; for though he had been used to go up ladders, he had never gone up one that was nearly so high. He felt an unusual sensation of giddiness in his head. He was glad the man was close behind him, he held fast to the sides of the ladder, stepped up very carefully, and seized his father's hand, who was waiting for him at the top. When landed safely on the roof of the tower, he looked about him: when he looked down, his head still felt a little giddy, and it was some moments before he recovered himself sufficiently to think even of his Portable Barometer. Then he recollected, that, in his hurry to come up, he had forgotten to mark how high the mercury stood when he was on the ground. He did not like the thoughts of immediately going down the ladder again. It occurred to him, that it would do exactly as well, to mark the height at which the quicksilver now stood, at the top of the tower, and afterwards to see how much it would rise when he got to the bottom; but Lucy had his pencil and paper below. He wrote the figures on a bit of slate, which one of the men had in his hand. After being a little used to it, he grew quite at ease at this height, and could think as well as when on the firm ground. When he

was to go down the ladder, he was a little startled by hearing Lucy cry out, "Oh, Harry, take care."

His father stopped him, told Lucy she was very foolish to call out, desired her to go into the church, and wait there till they should come; which she did, and very glad she was, when she saw Harry and her father come down safely.

Upon examining the bit of slate, on which he had written his figures, and which he had put into his bosom while he came down the ladder, he found that they were so rubbed, that it was impossible to make them out.

Lucy, who was afraid of his going up again, was by turns sure, that one figure was an eight, a nine, or a nought.

This would not do for Harry, he must go up again. His father said he was right; and this time he wrote down what the barometer was before he went up, and carried paper and pencil with him. His father was so good as to accompany him. It was all done rightly, and this time Lucy did not say a word till Harry's foot was off the last rung of the ladder, and safe on the ground.

Now they knew exactly how much the quicksilver had fallen, in going up to the top of the tower, and at what it had stood at the bottom. Harry said, that this must be compared with a table of measures, which he had at home, which would tell the height, in feet and inches.

And here be it noted, that on this, and many other occasions, Lucy's readiness in arithmetic was of use to her brother, when he came to his calculations. The habit of writing her figures exactly underneath each other, in the right rows, and of drawing straight lines and making neat little figures, all proved of advantage when she was called upon to write down totals for him in a great hurry, or to go over and copy clearly his scrawled sums in addition, multiplication, subtraction, and division.

On the present occasion difficulties occurred, and Lucy sat beside Harry for a quarter of an hour, writing down and rubbing out figures upon a slate, and complying by turns with contrary orders.

"Lucy, my dear, write down 452, and subtract it from 930—have you done it?"

"Stay a bit—presently—yes."

"My dear, I meant to say *add*, did I say subtract?—no, add, add."

"Well, I have added."

"Now multiply that by—no, stay—first it must be divided—stop.—I do not understand this table: there is something about height above the level of the sea here, that I cannot make out. Then what is this *about expansion*?" continued he, reading. "Oh, my dear Lucy, we are all wrong. I do not know how to allow for the thermometer;

and here is a calculation about expansion and proportion, and heaven knows what. Oh! it is all wrong—I do not know what I am about.”

This Lucy had suspected, but she had the good nature not to say so; and as all she had done was right, she found it easy to be patient. Harry ran to look for the article *Portable Barometer*; no, *Barometer, Portable*, in a Cyclopaedia; but there opened to Harry's eyes such a quarto scene of tables, and fractions, and algebraic signs, as quite dismayed him, and Lucy stood in stupified silence beside him. At length he observed,

“There is a great difference between having a general notion of any thing, and knowing it thoroughly. I thought I understood the use of this barometer perfectly, but when I come to try, I cannot make it out well.”

“It is too difficult,” said Lucy; “you will only puzzle yourself”—(she offered to shut the book).

“No, no, I will try and puzzle it out, and when papa comes in, he will help me, and show me my mistake.”

When his father came in, he did help Harry, and with his assistance, and patience, it was all made clear.

“But after all,” said Lucy, “though you have found out the height of the church, it was a difficult way of doing it, with all these calculations. Would not it have been easier to have measured



it by letting down from the top a string and a weight, a *plumb line*, as it is called, I believe? then you could have measured the string, and you would have had no difficulty."

"Very true," said Harry, "that would have been the easiest way in this instance, because we could get to the top of the church at once, and let down a plumb line; but consider, Lucy, when we want to measure high crooked mountains, miles high, with ins and outs, and ups and downs, how difficult that would be. Besides, this puzzle with the portable barometer would not plague me again: it was only because it was my first time of trial; and I am glad that we have conquered the difficulty."

"It is very good of you to say *we*, for I did nothing but write down the figures, and do the sums," said Lucy.

"But that helped me very much, and thank you for doing it so patiently. You did not yawn above six times. And now, my dear Lucy, if we had but a mountain to measure!"

"How happy we should be going to the top of it together, at any rate!" said Lucy.

HYGROMETER.

---

“LUCY, your hair is hanging into your eyes this morning,” said her mother.

“Yes, mother,” said Lucy, “because it is quite out of curl.”

“Did you curl it last night, Lucy?” said her mother.

“Yes, mamma, I did indeed, and it curled very nicely this morning early; but I went out in hopes of meeting my uncle, who was to have come to breakfast, and by the time that I came in again, my hair was all as you see. The breakfast bell rang, and I had not time to curl it again.”

Her mother was satisfied, since Lucy had not neglected to curl it at night, which had sometimes been the case. Her father asked if she knew what had uncurled her hair when she went out.

“The damp of the morning, papa,” said she: “*my* hair always goes out of curl in damp weather.”

“So does mine, Lucy,” said her mother. “It is not peculiar to your hair to go out of curl in damp weather.”

“But, Lucy, what do you mean by your hair going out of curl?” said her father.

“Just what you see, papa; that it hangs straight.”

“You told me the moisture of the morning uncurled it; do you know how or why it does so?” said her father.

“No, papa, not in the least; I wish you would tell me.”

“When your hair is curled, the parts of one side of each hair are pressed close together, and the parts on the other side are stretched out. Give me that piece of packthread.”

It was loosely twisted. He coiled up a bit of it, and showed her, that in the inside of the coil the parts of the cord are pressed together, and those on the outside are stretched asunder.

“Now I see,” said Lucy; “and you mean, that it is just the same with my hair when I curl it. But still I do not understand how the damp straightens it.”

“That you shall see directly,” said her father; and he dipped the curled packthread into a cup of water; when it was all wet it became straight.

“Yes, it has uncurled, like my hair,” said Lucy. “But how?”

“Look, and you will see, that the water has filled all the interstices, or vacancies, which you observed between the different parts of the cord. Now there are in your hair, and in all hair, pores, or small vacancies, which can be filled with moist-

ure, like the interstices in this packthread, and which imbibe moisture from the air, as this packthread imbibed the water, which, you see, has filled the pores on the inside, as well as on the outside."

"Thank you, papa," said Lucy, "that is very nice. To know why my hair uncurls is at least a comfort. Now I understand it all."

"Not all," said her father. "There is a property of hair which you do not yet know; that when it is wet, that is, when its pores are filled with moisture—"

"I see, papa; you mean it swells out, and becomes thicker, like this cord."

"Not exactly like that cord, Lucy; that cord shortens as it swells out in breadth; but hair lengthens when it is moist. All human hair is easily affected by moisture."

"Very easily, indeed," said Lucy, dividing her uncurled locks on her forehead, and trying to put them out of her way. "I was not in the damp above ten minutes, and yet you see how straight my hair has become. Indeed, papa, as you say, human hair is very easily affected by moisture."

"Yes, fortunately," said Harry.

"Fortunately!" repeated Lucy; "unfortunately, you mean. Why do you say fortunately?"

"I have a reason, and a good one," said Harry. "It is fortunate that hair has that property. For one reason, for one purpose, useful

to all men and women, but especially to men of science."

"Fortunate and useful!" said Lucy. "Brother, how can it possibly be fortunate or useful to you, or to men of science in particular, or to any body, that my hair should so easily go out of curl in damp weather?"

"Not your hair in particular, Lucy, but hair in general," said Harry.

"What use," said Lucy, "if every body's hair in the whole world was to go out of curl like this every damp day—what use could it be but to make them all look very deplorable, as mamma says I do when my hair is in this condition? What good would this do to men of science, or any men?"

"You do not seem to understand me," said Harry, smiling. "Did you never hear of an hygrometer?"

"Hygrometer!" said Lucy, "Yes, I have often heard of an hygrometer. I heard papa talking to you about hygrometers very lately, and reading a great deal, last Wednesday—no, last Thursday."

"No matter, my dear," interrupted her father, "what day you heard me reading about it: do you know or do you not know what an hygrometer is?"

Lucy confessed she did not know *exactly* what it was; but she thought it had something to do

with a barometer and a thermometer, because it ends in *meter* ; and she remembered long ago her father had told her, that *meter* meant *measure*, and comes from some Greek word that means to measure ; therefore, she supposed an hygrometer must be a machine, or an instrument for measuring something, but what, she did not know ; she guessed it was something about the air.

Her father said, that she was so far right in thinking that it is an instrument used to measure something. He told her, that it measures moisture in the air ; and the name hygrometer is composed of two Greek words, *hugros*, *moist*, or moisture, and *metron*, *measure*.

Lucy liked this name, which contains, as she observed, the history of the thing ; and now she knew this, she thought she could never forget it.

Their uncle had not yet come in to breakfast, and their father beginning to read the newspaper to their mother, Harry and Lucy went on at the farther end of the room, talking to each other.

“ Now you can guess,” said Harry, “ why I said that it was very lucky that your hair uncurls so easily in the damp. You observed yourself, that you could always know by your hair whether it is a damp day or not, whether air is moist or not.”

“ So hair is an hygrometer,” said Lucy, “ for it measures moisture. I am sure my hair might say,

if it could speak Greek, *Hygrometer*; or, in plain English, *moist—I measure.*”

“Very true,” said Harry; “but still you do not know the measure exactly of HOW moist, how damp the day may be; do you?”

“Yes, in very, very damp days my hair comes quite out of curl, as you see it now,” said Lucy, “and hangs quite straight; but it only comes a little out of curl on days that are only a little damp or damp-ish.

“A little damp! ‘Damp-ish!’” repeated Harry; “that is very well for common talking, but it does not describe exactly how damp. I do not know what degree of moisture you mean to express by *damp-ish.*”

“Pish!” echoed Lucy. Harry would not smile.

“You have not yet told me, Lucy,” said he, gravely, “how the hygrometer is made to show the measure of moisture exactly.”

“I do not know *exactly*, brother. But suppose, for instance, you knew how long my hair is when it is quite dry; then in damp weather when it is moist, and hangs straight, you could measure how long it has grown; I mean how much it has lengthened by the damp.”

“I could measure,” said Harry, “but how?”

“You could see whether my hair comes down as far as to my eyebrows, or only this far, or this

far," said Lucy, touching different points on her forehead. "If I had a looking-glass I would measure this for myself."

"This might do," said Harry; "but at best it would do only for yourself; and but badly for yourself, because you must, to mark your points, have disagreeable spots on your forehead always."

"I should not like that," said Lucy, "nor would mamma, I am sure."

"Besides," continued Harry, "it would be rather inconvenient to me to run in search of you, with a pair of compasses and my ruler, to measure your hair and your scale on your forehead. This would be rather an inconvenient hygrometer."

"Rather, I acknowledge," said Lucy, "you would twitch all the hair off my head too, in measuring each hair, I suppose; and I should be afraid that you would put out my eyes with the points of your compasses, when you came to measure the scale on my forehead. I should not like to be your hygrometer."

"I would much rather have one that would always stand or hang in my room," said Harry; "or one that I could carry about in my pocket, better still! Could you manage that for me? Could you find out how to do that? I found out how to do it."

"Did you indeed, brother? and do you think I can?"



“ Yes, if you think well, and if you go on thinking,” said Harry.

“ I will, then. But tell me exactly what I am to think about, and what is to be done,” said Lucy.

Harry pulled a hair out of his own head, and laid it on a piece of white paper before her. “ There,” said he, stretching it out, “ you see its length. We will suppose this hair is as dry as it can be. Now I will dip it into this bason of water. Now that it has been wet, it is longer than it was when it was dry.”

“ Yes ; but we want to know how much longer,” said Lucy. “ Well, it is easy to lay it on this sheet of paper, and measure, as exactly as you please, how much longer it is when it is wet than it was when it was quite dry.”

“ Very well, ” said Harry, “ and I can tell you, that you would find it to be one fortieth of its length longer. Then you have the utmost length between extreme moisture, and extreme dryness.”

“ And,” continued Lucy, “ I could divide this line on the paper between the two black dots, by which you marked the points to which it stretched when it was dry, and when it was damp ; and, if divided exactly, it would be what you call a scale ; you could measure how much, in different degrees of damp or dry, it stretches or shortens.”

“ Very well, indeed,” said Harry ; “ and the scale on paper would be better than on your forehead, you see. That’s one point fixed.”

“That’s one point gained,” said Lucy; “now what is to be done next?”

“Next, you are to find out how, without the trouble of continually plucking hairs out of my head or yours, and wetting or drying, and measuring them, you might know every day or hour, or at any time you please, how damp the air is, or how much moisture it contains.”

“If I could but make the hair measure itself,” said Lucy, “and mark or show how far it shrinks or lengthens on this paper in any time.”

“Aye, if you could,” said Harry, “that is the question.”

“Suppose I had a very, very, very little weight,” said Lucy; “so little, that this hair could support it without breaking, then I could tie it to one end of the hair, and hang the hair by the other end to something, suppose a piece of wire stuck into the wall: and I would put this paper, with our scale upon it, against the wall, just behind the weight, and when you look at it, you would see how much the hair had shrunk or lengthened, at any time, in damp or dry.”

“There papa!” cried Harry; “Lucy has made out as far as I did the first time I thought of making an hygrometer!”

Lucy looked much pleased with herself, and with her brother for being pleased with her.

“And have I really invented an hygrometer, Harry?” cried she.

“Yes, but not a perfect one, my dear,” said Harry; “there is a great deal more to be done.”

“What more?” said Lucy.

“To come to breakfast, in the first place,” said her father.

This Lucy was ready to do, for she was a little tired; but by the time she had refreshed herself by eating half her breakfast, she returned to the question—“What more is to be done, brother, about the hygrometer?”

“To make it more convenient,” said Harry. “In your way, it must always be stuck up against a wall; and besides, your divisions are so very, very small, that you can hardly see how much the hair lengthens or shortens.”

“You might take a magnifying glass,” said Lucy.

“Well, that would help; but cannot you think of another way?”

Lucy thought for a little while, and went on eating her breakfast, and presently answered, “No, brother; I can think only of taking a larger magnifying glass, a glass that magnifies more. Will that do?”

Still there is an easier method; put the magnifying glass out of your head.”

“It must be a more difficult, instead of an easier way, for I cannot find it out,” said Lucy.

“But it is easier, I assure you, when you have found it out,” said Harry. “Come, I will help

you a little," continued he, after she had considered for some time. "Look at the hand of that clock," and he pointed to the dial-plate of a pendule, which was on the chimney-piece opposite to the breakfast table. "Look, the hand now points at ten. Do you see how far it is from ten to eleven? Suppose that hand was to move from ten to eleven?"

"Well, suppose," said Lucy; "I can easily suppose this."

"Then which would have moved the farthest? which would have gone over the most space? the point of the hand, which is at the outside of the dial-plate, or that part of the hand which is closest to the centre?"

"The point of the hand, which is at the *outermost* part of the circle, would have gone the farthest; I mean, would have moved over the most space. The part nearest to the centre would have moved so little, that I suppose I should hardly be able to see or measure by my eye how much."

"True," said Harry, "you could not; but you could see, and you could measure the space from ten to eleven easily; could not you?"

"Certainly," said Lucy.

"You could guess the measure even by your eye, without taking compasses or magnifying glass," said Harry.

"Now I see what you are about," said Lucy; "I must have a little, *leetle* hand, and dial-plate,

for my hygrometer, to show and to measure the least motion of the hair in shortening or lengthening."

"Right," said Harry; "so far right."

"Do not tell me any more," said Lucy; "I can do it all for myself now, and in a minute."

"Do not be in such a hurry, my dear," said Harry, "or you will never do it."

"Hurry! I am not in the least hurry," said Lucy, "only I like to be quick. Well, I would fasten the end of the hair to the axle, so as to make every, the smallest, motion of the hair move the hand."

She paused. She was not quite clear of the manner in which this was to be done.

"I will help you," said Harry. "Suppose—"

"Suppose," said his mother, "that you were to let Lucy finish her breakfast."

"I will, and welcome," said Harry; "for now she has the principle of an hygrometer, which papa was explaining to me the other day, and of which I will show her a plate after breakfast—"

"A plate!" said Lucy; "I may as well have the plate at breakfast, may not I?"

"By a plate, I mean an engraving," said Harry; "did not you know that?"

"Oh! yes, to be sure," said Lucy; "I was only in play."

HYGROMETER.  

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BREAKFAST finished, Harry went to the library to look for the book, and Lucy followed, eager to see the drawing and description of what she had been trying to invent. He showed her in Rees' Cyclopaedia two engravings of different hygrometers.

"This," said he, pointing to one, was invented by a great English engineer, of the name of Smeaton; and this other by Monsieur de Saussure, the famous Swiss traveller. Yours, Lucy my dear, is not exactly either of these; it is most like Smeaton's, but he uses a cord, with a weight hung to it, instead of a hair. It is said, however, that a hair is better than a cord for our purpose."

"And how does the other man, M. de Saussure, manage with the hair?" said Lucy.

Harry pointed to the engraving, and showed her, that one end of the hair is fastened, as she had proposed, to the axle of the hand, and the hair wound round the axle; but the other end, instead of having a weight hung to it, is strained tight, and fastened to a frame of wood below. Then, when the hair shortens or lengthens, with

dryness or moisture, it turns the axle of the hand a little, or much, according to the shortening of the hair.

“Turns the axle of the hand!” repeated Lucy. “I see it would turn, when the hair shortens, because that would pull it round; but I do not see how, when the hair lengthens, that it would turn back the axle and the hand. I think that the hair would only loosen round the axle.”

“True, Lucy, and accurate,” cried Harry, with pleasure in his eyes; “but look again at this engraving. See here a weight hanging to this little cord, which is wound round the axle, in a contrary direction to the hair. The weight is just enough to keep the hair constantly strained, so as to prevent it from loosening, as you rightly said it would, round the axle, if there was not any thing to prevent it, when the hair lengthens from moisture. Then, as it is kept stretched, it turns the axle and hand.”

“Yes; now I see no difficulty,” said Lucy; “I understand it quite; and I am glad I told you the difficulty, for you have cleared it away. I hate to feel that I have only half understood, and to leave off in a puzzle. But, Harry, here are prints of a great many more hygrometers.”

“Yes, made of different substances,” said Harry; “many things beside hair, you know, can be used to show the changes of moisture and

dryness; all things which show these easily. Some of them we have observed ourselves often."

"Oh! yes," said Lucy; "salt and sugar, for instance, and some kinds of wood, which *warp* with the changes of the weather from wet to dry. The wood of this window frame, I remember, was swelled so much during the rain last week, that we could not open the sash."

"Yes, that sash is made of deal; the wood of fir tree, you know," said Harry; "and this sort of wood shrinks and expands quickly with dryness and moisture."

"I recollect," interrupted Lucy, "I read something about a creeping wooden hygrometer, in the notes to the Botanic Garden. My dear, I remember it perfectly, because it was entertaining. There was a wooden automaton, a machine that moved of itself—"

"I know of no such machine," interrupted Harry. "If it moved, it must have been moved by some cause."

"Well, the damp, I suppose, was the cause. Now let me go on, Harry. It was a wooden automaton, with a long back, and four feet, with iron-pointed shoes, which clawed on little by little, so that it walked, or crept, or clawed, quite across the floor of its master's room, in a month's time, from the changes of damp and dry. I do not know how, but it was very entertaining, and it will



entertain me now much more if you can show me how it was contrived. There was, I remember, something about glueing the bits of wood that made the back, I do not rightly know how," said Lucy, "cross-ways."

"Cross-grain, I suppose you mean," said Harry. "We will look for it by and by, and I will try if I can understand and explain it to you. But now go on, and guess some other substances of which hygrometers are made."

"I do not recollect any more; help me a little," said Lucy.

Harry pointed to his mother's harp.

"I see mamma's harp," said Lucy, "but that only puts me in mind of the last tune she played."

"Do not you recollect that a string broke yesterday?"

"Yes, I do, and how troublesome it was!" said Lucy; "I remember that Mrs. ——"

"Stay, now, do not go to Mrs. Anybody, but think of the cause of that string breaking."

"Mamma said, that it was cracked by the sudden change of the weather."

"What change?"

"From dry to damp, I believe," said Lucy. "Oh, now I understand it; and I know what you mean. In damp weather the moisture from the air gets into the strings, and swells them out, and

so shortens them that, if they are held tight at each end, they crack. Those strings are made of catgut. Catgut then would be a good thing for an hygrometer."

"Yes," said Harry; "but now I will tell you another thing used for hygrometers, which I do not think you could guess—Ivory."

"Ivory! no, I never should have thought of that," said Lucy. "I never knew that ivory lengthens and shortens in damp or dry weather."

"It does though," said Harry; "there are a great many pores in ivory; we cannot see them without a magnifying glass, but the moisture gets into these pores, and swells it out. But now, Lucy, there is another common thing, which you see every day, which you might guess. When you dip it in water you may see its great pores swelling, without any magnifying glass; and then, when you squeeze the water out, and dry it, it shrinks so that you could hold in your shut hand what, when full of water, was as large as my head."

"A sponge! a sponge!" cried Lucy. "But if a sponge is left in a room by itself, would it suck up water from the air?"

"Yes, whether it is left in a room by itself or not," said Harry, "it will absorb (do not say *suck up*) moisture from the air; and it grows heavier when it is filling with moisture, or lighter as it

dries. The sponge hygrometer is measured, or measures by weight, not by lengthening or shortening, expanding or contracting. You do not look as if you understand this, Lucy."

"I do," said Lucy; "but I am growing tired. I think I have had enough about hygrometers."

"No, no, you cannot be tired so soon; guess once more," said Harry; "you may easily guess this, because it is a thing used in your dress."

Lucy had observed, she said, that her gloves often grew damp in wet weather. She guessed leather. It was not what Harry meant; but he said that he thought leather would do, and he did not know why it had not been used; perhaps as it takes in moisture so easily, it may not expand or contract equally."

Encouraged by Harry's approbation of her good guess of leather, Lucy was willing to try and guess again. "But help me," said she.

Harry told her, that the thing he meant is stiff, and yet not so stiff but that it can be bent; it is springy and elastic.

She thought of several things which can be bent, but she could not guess right; and then, yawning and stretching herself, she repeated that she was tired, and that she could not guess any more; Harry must tell her.

"Then I will tell you—whalebone, my dear. Come, have done yawning," said Harry; "I will

not make you guess any more ; now I will show you something entertaining ; I will show you a nice little hygrometer, made of an Arabian oat's beard."

"Show it me," said Lucy, stopping in the midst of a full stretch.

"Here, in this print," said Harry.

"Only a print! I thought you had the real beard," said Lucy.

"You might make an hygrometer yourself, I dare say, of a common English oat beard," said Harry.

"Well, that I should like," said Lucy ; "You were right after all, Harry, when you said it was lucky that my hair uncurled so easily. How odd it is, Harry, that I have been carrying all my life on my head, without ever thinking of it till this morning, one of the best of hygrometers! My having an hygrometer without knowing it, is like the man who talked prose all his life without knowing it."

"I do not know what man you mean," said Harry ; "come now, look at it, this Arabian oat hygrometer, Lucy ; it is the great Doctor Hook's."

"I do not care about the great Doctor Hook," said Lucy ; "but let me tell you about the man who talked prose without knowing it. He was a man in a play, a very entertaining play papa

was reading one evening when you were not listening.

“There was a maid-servant teaching her old master his letters, and asking him what he does when he says the letter u. Now you shall be the old man, and I will be the maid, and I will teach you. Say u.”

“Nonsense, my dear,” said Harry.

“Not at all nonsense,” said Lucy; “you may ask papa.”

“Well, but I have not time now,” said Harry

“And the maid taught him to fence,” continued Lucy; “if I had but a stick, I would show you.”

“Now your head is gone quite off to the play. I shall have no more good of you,” said Harry, looking mournfully. “But here comes my uncle,” continued he, as his uncle at this moment entered the room. “Uncle, will you look at this hygrometer for me?”

“I will, Harry, with pleasure,” said his obliging uncle.

“And so will I, Harry,” said Lucy, “to oblige you. My head is come back from the play now.”

For about three minutes she was attentive, and she understood and admired, to Harry’s heart’s content, the Arabian oat hygrometer.

“Now, Lucy, I will show you a much better,”

cried Harry; "one which is made of a kind of Indian grass, which grass is extremely sensible."

"Extremely *sensible* grass!" interrupted Lucy, laughing. "Uncle, I never heard of extremely sensible grass before! Did you?"

"I think *you* are not extremely sensible now, my little niece," said her uncle, "to begin punning, instead of minding what your brother is telling you. Surely you know that sensible means sensitive, that is, having quick, or great sensibility. You know these words are applied to plants, for you have heard of the sensitive plant."

"Oh! yes, to be sure, uncle," said Lucy; "I was only playing. I know the two meanings of the word sensible as well as any body; and I have not only heard of the sensitive plant, but seen it at aunt Pierrepont's; and not only seen it, and its leaves closing up, and shrinking back from my touch, but what is more, uncle, I have learned by heart Dr. Darwin's lines on the sensitive plant, the *Mimosa*."

She repeated them, and her uncle said, that they were pretty lines, and that she repeated them well.

"And would not they make a good motto for an hygrometer, uncle?" said she.

"Very good," said her uncle.

"And now," resumed Harry, "let me show you this hygrometer."

“One other motto, my dear uncle, I have thought of for the barometer,” continued Lucy: without considering how much she was trying her brother’s patience, she went on repeating, while she held her uncle by the flap of his coat,

“You charmed, indulgent sylphs, their learned toil,  
And crown’d with fame your Torricel and Boyle.”

“*Torricel!*” cried Harry; “I suppose you mean Torricelli.”

“No, it is Torricel in the lines, I assure you,” said Lucy.

“It is Torricelli out of the lines, I assure you,” said Harry. “There never was such a man as Torricel, was there?”

Their uncle whispered to Lucy, that Harry was right.

“Well, never mind, it must be Torricel here, for the sake of the line,” said Lucy, “else it would be too long. Let me go on; I will tell you what the indulgent sylphs taught these people.” She went on repeating.

“Beautiful lines, Lucy,” said her uncle; “but I am sure you cannot understand them, as you are not yet acquainted with the air pump.”

“But Harry is,” said Lucy, “and he will explain it to me; will not you, Harry?”

Harry looked very serious, sighed, and said nothing.

“Why do you sigh, Harry?”

“Because,” said her uncle, “he is afraid that he shall never be able to make you understand the air pump, or any thing else, if you are not more attentive.”

“Harry, I beg your pardon,” said Lucy. “But you know I was very attentive at first.”

“And will be very attentive at last I hope,” said her uncle. “Come, we will both be serious,” added he, sitting down at the table; and drawing Lucy towards him, he seated her on half his chair, put one arm round her, and leaned his other on the table, in an attitude of attention. “Now, Harry, explain your hygrometer, and spare the remains of that poor pen.”

“But Lucy looks tired,” said Harry. “Have you a mind to see the hygrometer, or not?”

“I have a *little* mind,” said Lucy; “that is, I have a *great* mind to please you, brother, only we need not go through them all,” said she, as he placed the plates before her.

“No, do not be frightened,” said Harry; “I am not going to show them all to you; I am going to show you only the very best.”

“Stay,” said his uncle, putting his hand over the engraving to which Harry was pointing. “Do not show her that, show her any other, she must not yet see that.”

“Why not? I wonder why!” said Lucy.



“I have a reason,” said her uncle. “But never mind or think about that which I hide under my hand, my dear; attend to what your brother is going to show you.”

“Which shall I show her, uncle?” said Harry; “shall I show her De Luc’s ivory or whalebone hygrometer?”

“The whalebone, for that is the most simple, I think,” replied his uncle.

Harry, with the article Hygrometer before him, began:—

“Look here, Lucy, do you see little *a*, and little *b*; this represents a small thin bit of whalebone, cut across the grain; you know what is meant by the *grain* of the whalebone; but do you see little *a* and little *b*?”

No; Lucy, instead of looking at little *a*, *b*, was peeping at the back of the page, and reading something about a little man, and a little woman, and a weather glass.

“Here is something very entertaining, brother,” said she, “I must read it to you.

“‘In the Dutch toys called weather glasses, one end of the index supports a small image of a man, and the other of a woman. The former appears, or is brought out, in bad weather; the latter in fair weather.’

“I remember,” said Lucy, “that once, at our widow Green’s farm, I saw a weather glass of this

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sort ; but I was not then wise enough to know that it was called an hygrometer."

"There is no great wisdom in knowing that *name*," said her uncle.

"I wish you would show me how to make this thing, brother," said Lucy ; "that would be something indeed."

"I can," answered Harry, "and I will another day, Lucy ; but I can show you but one thing at a time. Now pray mind what you are about, because I have other things to do."

"Yes, Lucy, consider your brother's time," said her uncle ; "he wants to go to his own affairs ; pray mind what you are about."

"I will, I will indeed, uncle ; I will Harry," cried Lucy.

Harry began again with,

"Little *b* is a thin piece of whalebone, cut across the grain." He was going on with his explanation, and went through *c*, *d*, and *e*, confident that Lucy was following him ; but by that time he heard the sound of an ill-suppressed laugh, and, looking up, he saw Lucy with both her hands pressed against her mouth, to prevent her laughter from bursting forth.

"What can you be laughing at, Lucy?" said he.

"Only at the odd figures of the little old man and woman, in the weather glass, which I never can think of without laughing : the woman with

her cap and red ribbons all awry, and her eyes crooked too, and her arm a-kimbo, and her pipe in her mouth, doubled back against her snub nose, flattening it this way. Look Harry, look uncle!

Her uncle, instead of joining in Lucy's merriment, said gravely, that she was wrong to waste her brother's time, and that he was afraid she would never learn any thing of science, if she was not more attentive.

Her mother came into the room while her uncle was speaking, and Lucy looked ashamed and mortified: writhing as if with bodily pain, she said, "I did attend as long as ever I could, but I could not any longer, I was so shockingly tired."

"It was my fault," said Harry; "I kept you too long, and told you too much at a time; but I did that, because you told me you wanted to get on, and to learn all I had learned as quickly as possible."

"That is true," said Lucy; "I was wrong there, I confess."

"And since we are all confessing," said her uncle, "I suppose I should confess I was wrong in praising you, Lucy, for repeating those lines."

"Yes, indeed, my dear uncle, I think you were," said Lucy; "for that encouraged me to repeat more, though I knew my brother did not like that I should."

“I was wrong, I suppose, not to like it,” said Harry; “but I will try to like poetry better.”

“And I will not repeat it at the wrong time,” said Lucy. “But Harry, another day, you must not tell me such a quantity, and keep me so long *at it.*”

“I will not,” said Harry; “I know it was wrong; but I was so eager and happy myself. And besides, you said you wanted to get on fast.”

“Well, but I will be content to go a little slower, and not to do so much at once.”

“Right, my dear Lucy,” said her uncle; “the only way to be quick at last, in science at least, is to be content to go slowly at first.”

“You may remember, Lucy,” said her mother, “that was the way you began in arithmetic; you used to tell me every day, ‘Mamma, this is very slow work;’ but now you can go on with it quickly.”

“A great deal more quickly than I can, I am sure,” said Harry.

“Well, Harry, I will be as slow as you please in scientific things,” said Lucy.

“And I will never tire you again so sadly,” said Harry, “if I can help it.”

“I will never be tired again,” said Lucy, “if I can help it.”

“If I can help it,” repeated their mother, “is a wise and safe addition.”

HYGROMETER.

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THE next day, Harry and Lucy, having finished their morning's business, were anxious to return to the hygrometer, and to try their resolution of mutual forbearance. But they had taken no exercise this day. Their uncle advised them to run out to their gardens, and divert themselves for an hour or two.

"Remember," said he, "Æsop's good old fable, and excellent principle of unbending the bow."

"Yes, said Lucy, "the strings of mamma's harp never crack when she remembers to *let them down*, to loosen them in time."

After having refreshed themselves by an hour of that voluntary hard bodily work, which children of all ages agree to call play, and after they had rested and cooled themselves, while they gathered a basket full of their own strawberries, of which of course they ate a proper proportion to determine whether they were or were not ripe, they returned to the house, intending to offer these their first strawberries to their uncle. But not in the library, nor in the breakfast room, "nor up the lawn, nor at the wood was he;" and it was concluded, that

he was gone home to his own house, which was about a quarter of a mile's walk from theirs.

"We had better run after him with our basket," said Lucy.

"No, he will come back before dinner, I am sure," said Harry; "for mamma said he was to dine here, and there is his great coat still in the hall. Now let us go to the hygrometer."

Lucy set down her basket of strawberries at the farthest end of the room, lest the smell should disturb her, and Harry took down and opened his large volume. But their hands were in no condition to touch delicate engravings: his were brown with garden mould, and hers pink with the juice of strawberries. The dressing bell had rung, and their mother strongly advised their dressing before they began to read.

This advice, *to dress first, and then you are ready to do whatever you please afterwards*, so often given by age to youth, and so seldom taken, or well taken, was in this instance acted upon instantly, without one murmur of the tongue, or one writhing of the body.

In all the self complacency and safety of being ready half an hour before dinner time, they met again in the library, where they found their uncle.

"Oh! uncle, I am glad you are here," cried Lucy; and after presenting to him their strawberries, they went to their book.

Harry asked whether he should go on with *old whalebone* or not?

“Go on with old whalebone,” said his uncle. “Lucy should not leave that without understanding it: not that it signifies whether she understands that particular thing or not, but this will be a trial of her attention.”

“I will be very attentive,” said Lucy. But observing that her uncle placed his arm as before, so as to cover one of the hygrometers in the engraving, her curiosity a little disturbed her. Her uncle remarking the turn of her eye, said,

“I advise you, Lucy, to repress your curiosity. Do not think of what is under my elbow, but of what your brother is showing you.”

Lucy repressed her curiosity, and commanded her attention. Harry explained slowly, and she followed step by step patiently, undisturbed by the fear of being too slow, or the hope of showing that she was very quick; and without one glance at her uncle’s arm, or one thought of what might be his reason for keeping it in that position, she went regularly through the *a, b, c, d*, of De Luc’s whalebone hygrometer, and understood it to her own, and to her brother’s complete satisfaction. Her uncle was, as he said, glad to perceive that Lucy had so far kept her resolution; and he told her, that if she steadily went on in the same manner, she would find it in time easy to

do what she now felt so difficult, to fix her attention.

“And now,” said he, removing his arm from the print, “you shall know my reason for covering this, and I will show you what I went home for.”

He took from his pocket, and placed between Harry and Lucy, a small cylindrical case, of about three inches high, covered with morocco leather.

“It is like the case of mamma’s opera glass,” cried Lucy. “Is there an opera glass in it?”

“No ;” Harry smiled, for he knew what was in it immediately : he knew that it was his favourite hygrometer. His uncle took it out of the case, and placed it beside the engraving which he had covered with his arm, telling Lucy, that he had wished only to delay showing her the engraving, till she could compare it with the original, which he had walked home to bring for them. It was so simple, that, upon looking at it, and examining the plate, Lucy understood it directly. It is composed of a kind of Indian grass, which, like the beard of the Arabian and of the English oat, twists and untwists with dryness or moisture, but in a much greater degree, making, it is said, from ten to sixteen revolutions, from the extreme of moisture to the extreme of dryness. Harry told Lucy, that in the description which



he had read of this hygrometer, it is said, that it shows, more easily and quickly than any other, the changes of moisture in the atmosphere.

“It is so sensible,” continued Harry, “as to be affected by the shutting and opening of a door or window, and is sure to feel the approach of any person, and to indicate it by the motion of its hands.”

“Let us try now, if it will indicate my approach,” said Lucy.

As she approached, the hands began to move; and when, as her brother bid her, she took it up and held it nearer to her, the motion increased; and when, as he desired, she breathed through the holes in the sides, one hand, affected by her breath, seemed to fly round the circle, while the other numbered the revolutions. Lucy was pleased full as much even as her brother could expect. She stood watching its quick variations as she breathed upon it; or withdrew her breath.

“But, brother,” said she, “did not you tell me that this has been but lately invented? How comes that? Why did not people think of it before? Was not the grass always there, wherever this was found—in India?”

“I suppose it was,” said Harry; “but nobody had observed it. All I know about it is, that in Rees’ Cyclopaedia, it says, that this kind of grass was discovered in India about the year 1800, I

think, was not it uncle ? by Captain Kater, who was employed in making some survey, or some observations, and who wanted a very accurate hygrometer to measure the smallest quantities of moisture ; and he tried this grass, and found it succeed, and found that it lasts better and is more sensible than the English oat."

" Accurately remembered, Harry," said his uncle ; " but pray does the Cyclopedia tell you how it happened that Captain Kater took notice of this grass ?"

" No, uncle," said Harry ; " how was it ?"

" He told a friend of mine, that one evening, as he was walking without boots in that grass, he was annoyed by its frequent catching in his stockings ; and when he took them off at night, he found them full of this grass, which had twisted itself into them. When he pulled it out, he observed it particularly. Then his attention being fixed, he remarked the sensibility of this grass to moisture, and he thought of using it for his scientific purposes, as an hygrometer."

" How very lucky, that it plagued him that day," said Lucy, " by sticking in his stockings."

" How well it was, that he observed its properties, when he took it out," said Harry, " and that he thought of applying it to some good use. I am afraid I should have thrown it away without observing it : at night, particularly, I might have

been sleepy and tired ; and then, uncle, the world would never have had this nice little convenient instrument."

"Would you, Harry, and would you, Lucy," said their uncle, "like to have this nice little convenient instrument for your own?"

Their eyes brightening with pleasure, they answered that they should like it very much.

"Then it is yours, my dears," said their uncle. "I give it you in the hope that it will teach you accuracy and patience."

They said that they would try to keep a register of it regularly, but Lucy added, that if it was only to teach her patience, she should not like it so well as if she thought it would be also of some use to her uncle, or for some other purpose.

Her uncle assured her, that it would be useful to him; he said, that he had two friends, one living in Ireland, the other in America; they wished to keep a register of the damp or dryness of the atmosphere in those countries, to be compared with England.

"Then," cried Lucy, "we will keep the register for England with pleasure: that will be something grand, and worth while."

"But," said her uncle, "if you attempt this, it must be done with accuracy, or it will be of no use. Remember, I tell you, it will be a trial of your patience. Do not begin it unless

you think you can keep it regularly for six months."

"Half a year!" said Lucy, "that is a very long time." Harry, however, was not afraid to undertake it; because he had tried, and had kept a register of a barometer for a whole year. He said his register was not neat, though it was accurate; his figures were too large, and straggling often out of their proper columns; but now he could use Lucy as his secretary, and she could make nice even figures.

Their uncle wrote for them some necessary directions. He said, that it would be requisite every time they registered their hygrometer, to do a sum in division of a certain large number of figures. This did not alarm Lucy, for she was expert in division, and she rejoiced that she should be able to do this sum readily for her brother; and that she should be wanted and useful every day, or may be twice a day. They were eager to show their hygrometer to their father; but he had gone from home for a few days.

It was settled, that the first thing they should do every morning of their lives must be, to examine and write down their hygrometer registry. Harry was always to *read off*, and Lucy to write down.

Whoever has tried to keep a daily register, or to do any thing regularly every day, and at a

certain hour, must know, that it is not a very easy task; and where two persons are concerned, the difficulty is more than doubled, with the chances of one or the other failing in punctuality, and quarrelling about whose fault it might be. Harry and Lucy, therefore, by the experienced and the candid, will be allowed some credit for keeping their register accurately every day for a month, without having complained of each other. Lucy repeated, that she was very glad it was to be of some great use to her uncle, at the end of the time; for that, without this motive, and the pleasure of helping her brother, and of making nice figures for him, she confessed, that she should not have patience to go on with it.

“Thank you again and again, mamma, for allowing me to learn with Harry as I used to do. I am much happier already. But, mamma, if I knew ever so much, if Harry was not fond of me, and I of him, we could not be really happy. Could we, do you think, mamma?”

“In truth, my dear child, I do not think you could,” said her mother.

“I am sure, quite sure, we could not,” continued Lucy. “Suppose I knew all the histories, and all the poems, and all the stories in the whole world, and that I could draw, and play on the piano-forte, and dance better than any body in the universe, I am sure, mother, I could never be

happy unless I loved my brother, and he loved me. Nor could he be happy, even if he knew all the 'Scientific Dialogues,' and all the mechanics, and hydrostatics, and optics—

“But, oh!” cried Lucy, interrupting herself in this enumeration of the *ics*, “there is papa come home! I could not think, mamma, what made you start up so quickly in the middle of my *optics*.”

PUMP.  

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LUCY had too much discretion to produce their hygrometer the very moment her father came home; she waited till he had finished what he was saying to her mother; comprehending that this might be of more consequence to him, and more interesting, than even their new possession, and their new arrangements. As soon, however, as he had leisure to attend to her, he turned to Lucy, and holding out his hand to her, said, "Have you any thing new to tell me, my little girl?" she answered eagerly, "Yes, papa, a great deal!" He made room for her on one side of him, and for Harry on the other, and then they showed him their hygrometer; and Lucy told him how much she wished to understand what her brother had been learning the preceding years; and she told him of Harry's intention to bring her up to him in science. She promising to go as slowly, and he as fast as he could, and to tire her as little as possible. Her father was glad that Harry had learned by his first attempt, that he should not, on any subject, tell all he knew to his sister at once, nor expect that she could at

once take as great an interest as he did, on subjects of which she was ignorant; particularly when she had to endure all the labour and mortification, which a beginner must go through, before the study of any new science can be easy or entertaining. His father advised Harry not to attempt to describe all the small parts and detail of machines, not to go over all the *a b c*'s of descriptions in engravings, which, however requisite for those who are to make them, would be unnecessary to Lucy. He advised Harry to try to give his sister a clear knowledge of the principles of some of the most useful inventions and discoveries. He promised to assist whenever he came to any difficulty, but he desired him to try first how he could go on by himself, in explaining to his sister. And he repeated to Lucy what her mother and uncle had said to her about attention. He told her, that whenever he had attempted lately to teach her, he had observed that she did not attend as well as formerly.

“ I know it, papa; I try all I can, but I cannot. I do not know how it is, I cannot,” said Lucy; “ every word that is said seems, as it were, to awaken some other words; and every thing I see and hear, makes me recollect something else, and my thoughts are flying off backwards and forwards, and sideways and every way, while Harry’s can go on straight forward, always thinking of



what he is about, or of the very thing that is said to him. I used to be able to do the same," said Lucy, sighing.

"Sigh no more, Lucy," said her father, smiling. "No great harm is done. Your habits of attention have been spoiled, and your power of attending is consequently diminished; but with your own good will and good sense we shall soon set all this to rights again. Your perceiving and reflecting upon what passes in your own mind, will assist you very much."

"Papa," said Lucy, "I know how it all happened. Aunt Pierrepont did not think it signified much whether I attended strictly, as my uncle says, or not. She said I was quick enough. And I will tell you, papa, what made a great impression upon me. Once I heard a gentleman talking about genius; and he said of me, that he wondered how I learned every thing with so little attention; that I was always looking about and listening to all that people said, and yet that I was so quick. I am ashamed, papa, to tell you any more," said Lucy, stopping.

"You have said quite enough, my dear little girl, to prove to me that you are not quite a goose. As long as any person is ashamed of being flattered, there is hope that they will learn to despise and dislike flattery. I give up only those who get over the pain of the shame, and who then

like it shamelessly, and swallow down more and more of it, till at last they end by being fools to flattery, without knowing their wretched state."

"I hope I shall never be in that wretched state, mamma," said Lucy, with a look of much apprehension; "Harry, will you take care of me?"

"And of myself," said Harry.

"Well, now to business," said their father. "What do you wish to learn first, Lucy?"

She said that she wished to be made perfectly acquainted with the air pump, because Harry had reproached her with not having understood that fine poetic description of it, which she had learned by heart, and repeated. He said, that he could easily make her understand his uncle's air pump, because she already knew the principle of a common water pump.

"Do I?" said Lucy, smiling; "I did not know that I knew it;" and here she again thought of the man who had talked prose all his life, without knowing it; but she refrained from making an allusion to him, though it was ready on her lips. Harry recalled to her mind the experiments which their father had shown them two years ago.

"Do not you remember," said he, "the experiment he showed us, with a roll of tape that was put under a wine glass, which was turned down,

and plunged into a basin of water; and then the tape was pulled out, and unrolled by degrees?"

Lucy remembered all this.

"And what happened," said Harry, "when the tape was pulled from under the glass?"

Lucy answered, "That the water rose in the glass."

"And why?" said Harry.

"Because, when the tape was taken out, there was left in its place a vacancy, a vacuum you call it; then the water which was in the basin rose into that vacant place."

"And why did it rise?" pursued Harry.

"Because it was pressed by the weight of the air, pressing on all the water in the basin, and it was forced up into the glass where there was no air, nothing to prevent or resist it."

"Very well; now I am satisfied," said Harry.

"You remember it clearly."

"Because I understood it clearly at the time it was first shown to me," said Lucy; "my father was so patient, and explained it to me so slowly and clearly."

"Well," said Harry, "you have proved to me that you understand the first principle on which pumps are made, for all depends on making a vacuum, into which the water rises, or is raised. The first thing to be done is to make a vacuum. Now, Lucy, in a common pump, such as there is

in the yard for pumping up water, *where* do you think the vacuum must be before the water can rise?"

Lucy said, she supposed that it must be in the inside of the body or *tube* of the pump.

"Yes, we call it the *bore*," said Harry. "Now tell me how you would make a vacuum within it."

"Oh! my dear Harry, that is too difficult a question for me," said Lucy. "How can I tell how to make a vacuum in the *bore*, as you call it, of a great pump?"

"Where is the difficulty?" said Harry. "Do not be frightened by the word *bore*; or, if you are alarmed by the idea of a great pump, suppose a little one, as small as you please; as small, suppose, as the glass tube of the barometer."

"That would be easy to suppose; but could there be so small a pump?" said Lucy.

"To be sure, as well as of the largest size, only it would raise less water. But now go on straight forward, Lucy my dear; do not ask me any of your starting off questions. You must let me ask you questions, and you are to answer."

"If I can," said Lucy.

"You can, I assure you, my dear," said Harry, in his most persuasive tone, "if you will only believe that you can, and keep steady. I ask you how you would make a vacuum in this tube?"

“ Let me consider—let me recollect. What did my father do when he made a vacuum in the wine glass?”\* said Lucy to herself. “ He put in a roll of tape, which filled up the whole glass, and then drew it out, little by little, so as not to let any air into the glass, while he was pulling it out again. But I cannot get a roll of tape into the small tube,” said Lucy.

“ No, not a roll of tape,” said Harry; “ but if you consider what was the purpose or use of putting the roll of tape into the glass, and drawing it out again, you will perceive, that putting in and drawing out any thing else in the same manner would do as well.”

“ The purpose was, first to force the air that was in the glass out of it,” said Lucy, “ and to prevent any more afterwards from getting into the place which the tape took up, and which remained vacant as the tape was drawn out.”

“ Now you are coming on very well, Lucy,” said Harry.

“ If I can put in any thing of any sort into the little tube, which would force the air out, and then if I could keep the air out, there would be a vacuum for you, Harry.”

“ Very well, you will now quite understand a pump, and you will soon know how to use it, Lucy.”

\* See Early Lessons, Harry and Lucy continued.

“As to that,” said Lucy, “I know how to pump already, only I am not strong enough.”

“Stay! stay! Lucy; knowing how to pull a handle up and down, which I suppose is all you mean, is not understanding what I mean by knowing what pumping is, or how it is done.”

“I have seen men and maids often pumping at the pump in the yard,” said Lucy.

“What happens when they pump?” said Harry.

“The water comes out of the spout, after they have pumped a little while,” said Lucy.

“What do you mean by pumping?” persisted Harry.

“I cannot tell you exactly, Harry, because I never saw the inside of the pump. I only know that they move the handle up and down; and I believe there is something fastened to it, which I suppose brings up the water; but I do not know how exactly.”

“I believe not indeed,” said Harry; “then you see, Mrs Quick-Quick, you did not understand what I meant by pumping. Now come with me, and I will show you in my room the nice glass pump which my father made for me. You cannot see into the inside of the pump in the yard, but when once you have seen my glass pump you will understand the inside of all others.”

He showed her in the first place a glass tube,

in which there was a spout near the top. The tube was open at the top, and at the bottom there was a little door or valve, which opened upwards only: he poured water into this tube, to show her that the water would rest upon this valve, without its letting any of it through: he then emptied out the water. "Now," said he, "you know there is nothing but air in this tube. Look at this, which is called the piston of a pump." The piston was a hollow cylinder, which fitted tight into the tube: at the top of it there was a valve like that at the bottom of the tube, which also opened only one way, upwards. Harry pushed the valve up several times with his finger, to show Lucy that it opened easily, and he made her feel that it did so. He then put the tube into a tub of water, the tube resting on two blocks of wood, which raised it from the bottom of the tub, so that there was room for the water to flow in through the lowest valve. Lucy, as he desired, held the glass tube upright, while he pushed down the piston, to which there was a long handle.

"Now, Lucy, what happens withinside of the tube?" said Harry.

"Nothing that I know of," said she, "but that you have pressed the air in the tube closer together."

"Very true; do you see the valve at the bottom of the glass tube? Is it shut or open?"

Lucy said it was shut.

“And what keeps it shut?”

“The air that you are pressing down upon it,” said Lucy.

He pressed the piston down farther.

“Now look again,” said he, “and tell me what happens?”

“I see the little door at the top of the piston open,” said she.

Harry asked her what she thought had opened it.

“The air,” said she, underneath it, which I suppose you could not compress any more, and so it has forced up the little door in the piston and has made its way up.”

He now drew up the piston, and again asked what happened. Lucy saw that, as Harry drew up the piston, the valve at the top of the piston was shut, and that therefore all the air that had been pressed up through it, must be carried up by the piston.

“Oh now I know how you make the vacuum in the pump, and I see that the water rushed in and rose in the tube as you drew up the piston.”

Harry then plunged the piston down again, pointing out to Lucy that the valve at the bottom of the tube had closed, and that the valve at the top of the piston was open, so that the water which filled the tube came through it; and when he



drew the piston up, it carried the water up to the top of the tube, where it flowed out of the spout.

“Just as it does in the great real pump,” said Lucy.

“And now you do know what I mean by pumping,” said Harry.

He pumped on for some time, and then let her take the handle, and work for herself. He questioned her, and made her repeat her explanation, till he was satisfied, and she was satisfied, that she clearly understood, that the thing to be done in pumping, and by pumping, is to force the air out of a certain space, to produce a vacancy or vacuum, into which the water rushes and rises; “Or rather,” said Harry, “to speak more accurately, is pressed and supported by the surrounding air and water. Perhaps I ought to tell you, that there is no *perfect* vacuum. But I will not be too exact with you at first, lest I should tire you. Therefore I will not tell you all the differences between a lifting pump, and a sucking pump, and a forcing pump; besides, I am not sure that I know them all myself. I will not tell you even about water always finding its own level.”

“I am very much obliged to you,” said Lucy.

“Nor will I tell you,” continued Harry, “about the weight of the column of water, which a certain quantity of air can sustain.”

“I think I do know something about that,” said

Lucy; "or I did know it once. However, thank you for not telling me too much at a time, especially about all the different pumps you talked of. Leave my head quite clear with the vacuum. That I understand now, and the use which is made of it; and I understand all that happens when the piston of the pump is pulled up and pushed down."

"And now that you know," said Harry, "what pumping is, I will ask mamma to let us go to the great pump in the yard, that you may see, Lucy, the same sort of thing in large, that you have seen in small."

Their mother went with them to look at the pump in the yard. The handle was so high, that Harry could not well manage to use it; but his mother called for one of the servants, who pumped for them.

The servant filled a tub with the water, which he had pumped up; and, as he lifted it to carry it away, he said, that he and all the servants in the house were very glad that the pump, which had been out of order, was now well repaired, because it had been great labour to them to go to the windlass-well in the garden for water, whenever it was wanted, and to bring heavy tubs of it many times a-day. This observation made Lucy the more sensible, as she said, of the great convenience of a pump.

“This is a really and truly useful machine,” continued she; “useful to great, great numbers of people, for the commonest business, that must be done every day, and almost every hour; and it is as easy for ignorant people to use, as for the most learned—what an excellent contrivance! How happy the man must have been who made the first pump, when he found it would do, and felt the water coming, and saw it pouring out at the spout!”

“Delightful!” said Harry.

“Now, Harry, my dear, tell me something about the air pump.”

“No, no, my dear, that would be too much,” said Harry, looking very prudent. “One pump a-day is enough for *you*. I will keep the air pump till to-morrow.”

PUMP DISASTERS.

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AFTER all this wisdom, what did they do next? How did Harry and Lucy spend the remainder of this morning, two whole hours?

If we tell, we shall not be believed, except by those who are themselves children, or by those who know children right well, and their sudden falls from the heights of wisdom to the depths of folly.

Harry and Lucy spent all that remained of this morning in pumping up, through the little glass pump, the water of a puddle in Harry's garden. They could have ladled it all out in three minutes, and two moderate sized tubs would have held it, and have carried it all away. But this would have been too obvious, too easy a way of going to work. It must all pass through the glass pump: and so they worked on till their backs ached, and till the dirty puddle water had so soaked into the leather of the piston, and so clogged the valve with mud, that it would move no more.

During this pumping and draining of the puddle, many misadventures befell Harry's trow-

sers and Lucy's clean frock—clean no more! It may be recorded, for the advantage of little washerwomen, who, with hands unskilled, may unadvisedly attempt to wash out fresh spots, that the more Lucy tried to get rid of hers, the more they appeared. What seemed quite out while it was wet, came in again as soon as it dried. And the spots spread into blotches, with obstinate edges of yellow; so that altogether the frock, instead of looking better for these operations, was worse than ever!

Before it was half dry—oh how unlucky!—before it had half dried, after dip and scrub the fifth, the sound of carriage-wheels was heard—morning visitors! Their garden was full in sight of the house. Up jumped Harry, upon what he called his throne, a heap of stones, from whence he had a full view of the carriage. It was one he had never seen before. Lucy clambered after him, to share the exalted view from his throne, and to assist his judgment with her eyes and her imagination. A lady was getting out of the carriage. Lucy did not know who it was, she confessed, but she imagined that it must be a certain Mrs. Hanbury, who owed her mother a visit.

“I am sure it is Mrs. Hanbury, and I dare say that her daughter is with her; therefore I will not go in, for Miss Hanbury is always very fine, and I should not like that she should see me in this frock

in this sad condition. And oh! Harry, they must not see you in those trowsers. I will show you how Mrs. Hanbury and Miss Hanbury would look at us. We will not go in."

"Go in! upon no account," said Harry. "As to my trowsers, I do not care what your fine Miss Hanbury or Mrs. Hanbury think, or how they look at them, or at me; but I hate going into a room where there are strangers."

Harry observed, however, that notwithstanding Lucy's certainty, that the visitors were Mrs. and Miss Hanbury, no girl got out of the carriage, and there was a gentleman.

"How can that be?" said Lucy, "for there is no Mr. Hanbury. Let them be who they may, we will not go in," repeated she.

To this Harry heartily assented. He disliked *morning* visitors particularly.

"So do I; so does every body," said Lucy. "I hope they will not see us from the house. I hope mamma will not send for us. Harry, we had better sit up in your observatory, in the great sycamore tree."

"Come up then this instant," cried Harry. "Give me your hand, and I will pull you up."

In Harry's observatory, in the great sycamore tree, they both sat snugly for some time, till he saw through the branches some people standing at the drawing-room window. That they might

not be seen by these people, Harry advised leaving the observatory, and removing a step higher, into what he called his dark attics, where the branches were so thick, that he was sure no morning visitors could see them, or think of looking for them; he had sat there many a time, he said, while ladies had passed under the tree chattering, without ever spying him. Scarcely, however, had they mounted, and safely lodged themselves in the attics, which, to say the truth, were ill able to hold two lodgers at a time, when Harry exclaimed,

“It is all over with us! there is mamma herself at the window, beckoning to us.”

“But she cannot see us,” said Lucy.

“Certainly not,” said Harry, “unless she saw my white trowsers, when I was clambering up here into the attics.”

“White trowsers! Oh no, I am sure she did not,” said Lucy.

“But there she is,” said Harry, “waving her handkerchief, Lucy.”

“Do not go, do not go in; for now I have a green streak worse than all the rest,” said Lucy; “I am sure mamma does not see us, and I dare say she does not want us really herself, but perhaps Mrs. Hanbury asked for me, and mamma just beckoned.”

The signal was repeated at intervals, two or three times. Lucy had some doubts, but the fear

of Mrs. Hanbury's seeing her dirty gown prevailed. The handkerchief ceased to wave, and they remained in their tree nearly an hour, a much longer time than they had expected. Harry had been resolute from the first, and had no waverings during this hour. As he sat quite at ease in his tree, he said, "Now is a good time to think of the puzzle my uncle gave me, about a three gallon, a five gallon, and an eight gallon vessel." Lucy interrupted him several times, by scrambling up and down to see if the carriage was gone, or whether mamma waved her handkerchief again. At length, having succeeded in solving his problem, he held her fast by the gown, insisting upon her sitting still and thinking of it, which, as he assured her, would make the time appear to go much faster. "There was a gentleman who had two haymakers. One hot day they worked very hard making hay, and when they had finished the hay rick, late in the evening, the gentleman called them to his hall door, and said, 'My good men, you must be very thirsty, I will give you some beer to drink. Here are eight gallons for you; but you must divide this beer so that each of you may have exactly half, and this you must do before you drink a drop of it.'"

"That was very easily done," said Lucy; "each was to have four. What puzzle is there in this?"

"Stay, stay, Mrs. Quick-Quick, you will be



puzzled yet before you have done. The gentleman had only three vessels in his house, it is said; the first held eight gallons—the beer was in this; the second held five gallons, and the third three gallons, and these two were empty. Now manage it as you will, Lucy; and with these vessels divide the beer so that you can prove to me, that each man has four gallons exactly. You may pour the beer backwards and forwards as often as you please, from one of these vessels to another.”

Lucy began, and poured from one to another in imagination for some time, without success; pour how she would, there was at the end of her measures always five gallons in the eight gallon vessel, and three in the five. At last she perceived how it could be done, and showed how she could prove to Harry that she had divided it equally; “four gallons, Harry, in the eight gallon vessel, and four gallons in the five gallon vessel.”

So completely had her attention been absorbed by this puzzle, that she had not heard the sound of the departing wheels of the visitors' carriage; and when she again peeped out of their hiding place, they were surprised to see that the carriage was gone.

When they went in their mother told them, that she was sorry they had not sooner made their appearance, because the lady and gentleman who had been with her were remarkably agreeable

people, and had told many things that were entertaining and interesting.

“Then, mamma, it was not Mrs. and Miss Hanbury!” said Lucy; “how very provoking! I am sorry, mamma, we have missed hearing entertaining things. Who were the people?”

“Sir Rupert and Lady Digby, friends of your father’s.”

“I never heard of them before,” said Lucy.

“Very likely, my dear.”

“Mamma, what sort of entertaining things did they tell?” said Lucy.

“They gave us an account of a shipwreck, which happened lately on part of the sea-shore, near the place where they live.”

“Oh, mamma! tell it me,” cried Harry.

“Yes, pray, mamma,” said Lucy.

“First tell me, did not you see me beckoning and making signals to you to come in, my dears?” said their mother.

“Yes, mamma, we saw you,” said Harry; “but we thought that it would be tiresome, and we did not like to go in; I liked better to go on with what I was about.”

His mother told Harry, that she would not have beckoned to him unless she had thought it was worth his while to come in; “And,” added she, smiling, “you must now abide by your own choice, for I will never tell you of the shipwreck.”

“Pray, at least, mamma, tell it to Harry,” said Lucy; “because it was all my fault that we did not come in. I did not like to come, because—look at my frock, mamma.”

“It is very much soiled, indeed,” said her mother.

“With water from my puddle and my glass pump, mamma,” said Harry; “that was my fault.”

Her mother asked Lucy why she could not put on another frock. “Have not you any other, Lucy?”

“Yes, mamma,” said Lucy, colouring, “I have; but I could not put on any of them, because one is so short, it comes up to here; and I forgot to let down the tucks: and another has a great tear in it; I intended to have given it to be mended this morning: and one sleeve is half out of the third, mamma; I tore it last night, as I was reaching down a book from the uppermost shelf.”

Her mother said, that there must be no more experiments of any kind till Lucy should have these things mended.

“I know that is quite right, mamma,” said Lucy. “I expected you would say so. I will go up to my room directly, and let down the tucks. But, mamma, while I am away, *could* you be so kind as to tell Harry the story of the ship-wreck?”

“I *could*,” said her mother, smiling, “but I will not. In the first, place I should be sorry to tell it when you were not present; but I do not intend

to tell it to him at all ; for, if I were to repeat to him every thing entertaining which I heard this morning, he would depend upon my doing the same another time, and he would not exert himself to conquer that feeling of bashfulness, which prevents his coming into a room where there are strangers, and which makes him always say, ‘ I would rather stay out of the room, and go on with my own affairs.’ ”

AIR PUMP.

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“ Now, brother, for the air pump,” cried Lucy ; “ as you used to say ‘ Now, papa, for the barometer.’ ”

“ My uncle,” said Harry, “ has been so good as to lend me his portable air pump to show you. Was not it good of him to lend it ? ”

“ Very good, indeed,” said Lucy ; “ and how convenient to have so many things portable ! *Portable* barometer, *portable* hygrometer, *portable* air pump.”

“ Now, Lucy, recollect what was the great thing to be done in pumping,” said Harry.

“ Was not it to make a vacuum ? ” said Lucy, hesitating, as if she was afraid of making a mistake.

“ Yes, to be sure, my dear,” said Harry. “ Be quite certain about that.”

“ I am quite certain,” said she ; “ I was only afraid to say it at first, lest I should not be right.”

“ But do not be afraid. When you know a thing, know it very firmly. The truth cannot alter between yesterday and to-day ; nor can the truth ever alter, you know.”

“ That is a great comfort,” said Lucy. “ Was

not it Boyle who invented the air pump, or was it Torricelli?"

"Neither," said Harry; "it was that poetry you repeated, which put that mistake into your head. And when once one has got any thing wrong into one's head there is no getting it out again. But you are partly right. Boyle improved the air pump very much, and it is sometimes called the Boylean vacuum, that is, Boyle's vacuum. But Boyle was too honest a man to claim for his own the first vacuum. I mean the first making use of it for the air pump. He knew, and always said, it was Otto Guerick's invention."

"Well, I dare say it was," said Lucy; "you need not say any more about it. I do not care much who made the first vacuum, nor who first made use of it for the air pump."

"You do not! Lucy, my dear, consider what you say. Suppose I had invented the air pump, or something as great, would you, my sister, like that somebody else should take from me the honour and glory of the invention?"

"No, I should not," said Lucy; "but you are my brother, and alive; and to be sure I should be anxious that you were not robbed of the glory. But those other people, Mr. Otto Guerick and Mr. Boyle, are nothing to me; besides, they have been dead and buried long ago, and what signifies it now to any body?"

“It signifies a great deal,” said Harry. “Suppose it was my father, or my grandfather, or my great grandfather, should not I care? would not you? Then so would Otto Guerick’s, or Boyle’s children, or grandchildren, or great grandchildren, if there are any living. And there is a great family of Boyles, I know; and do you think that for the world they would give up the Boylean *vacuum*?”

“I suppose not,” said Lucy. “But now let us go on to the air pump itself, and the vacuum, let it be whose it will.”

“So we will,” said Harry; “but, before I show it to you, remember, that what you are going to see is a pump for pumping out air, not for pumping up water. So put water quite out of your head.”

“I have put water quite out of my head. I understand that the air pump is to pump out air. But, brother, before you begin, let me say one thing.”

“Say it then, if it is not poetry.”

“No, it is only that I think a pair of bellows is a sort of air pump. Hey, Harry?”

“Well, that is not foolish, Lucy. You may call a pair of bellows a sort of air pump; only that bellows never could be a right air pump without two valves. But do not go on thinking of them all the time I am explaining to you.

Now look at my uncle's air pump. You see this glass," continued Harry, and he pointed to a large glass bell, which stood over a sort of frame or stand. "Lucy, what do you think is in this glass?"

"Air, I suppose," said Lucy.

"It is full of air, and of nothing else," said Harry. "The thing to be done is to get all the air that is in the bell out of it. And that is to be done by means of these pumps," continued he, pointing to two tall cylinders of brass, which stood upon the stand with the glass bell; they communicated at the bottom with a pipe, which opened into the bell. There was a handle, by which, as he told Lucy, she could move the pistons of these pumps up and down.

"Just in the way in which the piston moved up and down in the water pump yesterday," said she. "I see, I see; it is all nearly the same thing, only that this pumps air out, as you said, and the other water. I understand it all perfectly."

"Stay, stay, Mrs. Quick-Quick, you do not understand it all perfectly yet. You see only the likenesses, but there are differences which you do not see yet, and cannot, my dear Mrs. Quick-Quick, because it takes a great deal more time to see the differences than to catch the likenesses, Mrs. Quick—"

She put her hand upon his mouth before he could repeat the offensive words.



“ Brother, do not call me Mrs. Quick-Quick, and I will be as slow as you please, and I will not tell you of any of the likenesses I see. I will be quite silent, and only nod my head, when I understand ever so perfectly.”

“ Then look at the air pump which is before you,” said Harry, “ and observe what I do. I am going to move the handle which you see at the top, which will raise up one of the pistons. What is underneath the piston ?”

“ Nothing,” said Lucy at first ; but afterwards she added, “ I believe there is a vacuum.”

“ True. And what happens directly ?” said Harry.

“ Air comes in directly to fill it, I suppose,” said she.

“ Where does it come from ?” said Harry.

“ It must come from the bell through this pipe,” said Lucy, “ which leads from the bell to the bottoms of the pumps.”

“ Then, when that happens, there is less air in the bell than there was before ; is not there ?” said Harry. “ Now move the piston down again, and what happens ?”

“ You would press the air that is under the piston back again up the pipe into the bell,” said Lucy, “ if there is not a valve at the bottom of the pump that shuts against it, and prevents it from going back. But, though I do not see it, I

suppose there is such a valve, because you told me that it was necessary in all pumps."

"You suppose rightly, and you remember very well," said Harry. "There is such a valve, and it prevents the air from going back into the bell when I push the piston down. But what becomes of the air?"

"It comes out into the open air through the valve in the piston, I suppose."

"Very true. Now I will move the handle again, and repeat the operation. I should have told you, that we are assisted in pumping by the expansive force of the air."

"I do not understand that," said Lucy.

"Yes, you do, my dear, if you will only recollect the experiments papa showed you with a bladder," said Harry.

"Ages ago?" said Lucy.

"Yes, you remember seeing the bladder swell out with the expansive force of the air; and you may recollect that, after blowing in air for some time, when we tried to force in more air we could not; the bladder swelled out so that we could hardly hold its mouth together to tie it."

"I remember it," said Lucy.

"If we had let go the string," said Harry, "and the mouth of the bladder had opened, what would have happened?"

“The air would have forced its way out,” said Lucy.

“Yes; air, you know, will expand, and fill every empty place. Now I have pumped out all the air that I can from the bell, and, now that it is as empty as we can make it, we call it a vacuum, though very accurate people would tell you, Lucy, that it is not a perfect vacuum.”

“It will do for me,” said Lucy, “and I think I understand the air pump really now. Is there any other difference between it and the water pump, brother? You said there was a difference.”

“I did say so, and I will explain to you what it is, if you will answer my questions patiently. What was it in the glass water pump that you saw yesterday, that pressed up the water into the vacuum below the piston?” said Harry.

“It was the outer air; the weight of the outer air pressing upon the surface of the water that was in the tub, forced the water up into the tube.”

“True; the same in all water pumps,” said Harry. “But here is no water for it to press upon. How then is this vacuum filled?”

“By the weight or force of the air itself only, I believe,” said she.

“What air?” said Harry.

“It must be the air in the bell,” said she, “for I see no other. But that is so little that there cannot be weight enough in that.”

“No,” said he, “it is not by *weight* that this pump acts, but by the *springiness* of the air itself. This is the difference which I wanted you to observe, between the air pump and water pumps.”

“By the springiness of the air?” said Lucy.

“Yes,” said Harry; “you felt the force of that springiness in the bladder when it was full of air.”

Lucy said she should like to feel it again. She had almost forgotten it. Harry blew into a bladder, and filled it with air, and when it was full bid her try to press it together; when she tried to do it she perceived the sort of resistance that it made, and she felt the force with which, after she had squeezed it, it returned to its former place and form.

“The same springiness,” said Harry, “or what is called the elasticity of the air in the bell, is what fills the vacuum below the piston, each time it is drawn up. Now here is the description and plate of the air pump in *Scientific Dialogues*, and this is all that you need know about it at present. Stay, I will just look at the print of it in *Rees’s Cyclopaedia*, and see if I have left out any thing that I ought to tell you.”

As he opened the book, and as Lucy saw the engravings, she looked a little alarmed.

“There seem to be as many different air pumps as hygrometers,” said she, sighing.

“Do not be afraid, I am not going to show them to you all,” said Harry; “but, now that you know the general principle, you would soon feel it easy, as I did, to understand them”.

“Oh no!” said Lucy, “there seem to be such a number of pipes and valves, and little *a*'s and *b*'s, and *p*'s and *q*'s.”

“They only relate to the contrivances to prevent the outer air from coming in, while we are pumping the air out of the vessel that is to be emptied, which it is constantly trying to do. One pump is better than another only as it does this most effectually and most easily, and as it more perfectly empties or exhausts the vessel. By the by, I should tell you that this glass vessel is called a receiver, and when it is emptied it is called an *exhausted receiver*. I was puzzled at first by those words, *exhausted receiver*.”

“Thank you, Harry, for remembering that for me.”

“Now, my dear Lucy, you shall work a little at the air pump yourself, as you did at the water pump yesterday.”

“Oh thank you, thank you,” said she, joyfully; “there is nothing like working oneself; it fixes a thing so well in my memory. I remember the look and touch of the things much better afterwards.”

While Harry was placing the machine, so that

it should be convenient to Lucy, she turned to look at the book of engravings, that lay open on the table.

“How well this air pump is done,” said she. “It is very like my uncle’s; not quite, perhaps. I will take care to mind about the *differences*.”

“This is very like it,” said Harry; “there is no difference of any consequence.”

“If we had not had my uncle’s,” said Lucy, “I think you could have made me understand the air pump quite well from this engraving; that is, after my having seen the glass pump yesterday, and its valve and the piston; but without that I could not have understood it from this representation; because I see here only the outside of a pump. Even though you had described the valves, and explained them to me ever so clearly, I should not have understood them so well as by having seen and touched them, and moved them myself.”

“Certainly,” said Harry; “but, next to seeing the real thing, these engravings or drawings help one very much. Look, though you see only the outside of the pump in that perspective view, here is the inside of an air pump, all laid open for you. You know what is meant by a section?”

“Oh! yes,” said Lucy. “Suppose any thing to be cut in two, what you see inside of each part, when they are separated, is a section. Papa

explained that, and showed it to me, when he cut a lemon in two for me. I remember this minute, as well as if it were before my eyes, the look of the lemon, with the pippins cut in half, each in their little cells, the cells cut open too; and I remember —”

“Very well, my dear,” interrupted Harry, “you remember very well what is meant by a section, therefore you will understand this plate and this figure. But, Lucy, never be ashamed to tell me if you do not understand; you know I have but just learnt these things myself, and I remember the odd mistakes I used to make, and the puzzles I was in when papa was teaching me.”

Lucy looked at the engravings now without alarm, because, as she knew what they represented, they did not puzzle her, and she was not afraid of being tired.

After having looked at the section, she said it made the whole as plain to her eye as if it had been made of glass. Something farther she said to herself, about a man's having a window in his breast; but either she did not say it loud enough for Harry to hear, or he did not think it much to the purpose, for without attending to it he shut the book, saying, “Now we have had enough of the prints. I thought just now you were very eager to work the air pump yourself, Lucy.”

“So I am still,” said Lucy; “only it was not

quite ready, and I looked at the prints between times. Now let me pump."

"Pump away; this way," said he, showing her how to hold the handle, and how to move it backwards and forwards, and how she worked two pistons at the same time.

She worked it, but not without difficulty. After she had pumped for some minutes, she found the difficulty increasing, and asked from what this arose.

Harry said, from the resistance made by the pressure of the outward air, which becomes greater as the receiver is more and more exhausted. He took off the receiver, and put her hand over the hole at the top of the pipe, which communicates with the pumps, and bid her move the pistons with her other hand gently. She did so, and felt that part of the palm of her hand, which was over the pipe, drawn in. Her brother repeated, "gently, gently," as she moved the handle. Indeed, soon there was no occasion to say so to her, for she felt the palm drawn in so as to be quite painful, and she grew red with fright.

"Oh! brother, it hurts me very much; I cannot take my hand away. What shall I do?"

"Stop pumping," said he, "and do not be frightened; there is no danger."

She stopped pumping, and her brother turned a screw, so as to let in the air. This relieved her



hand. She held it up to show him a purple circle on the inside of her hand.

He pitied it a little—a very little. Lucy thought not quite enough.

“ I know,” said he, “ exactly **how** much it hurts you, because I have done the same a hundred times to my own hand. My dear, I wanted you to feel as I did myself. There is, as you said, nothing like feeling, to make one remember well. What do you think caused this ?”

At first Lucy answered that she did not know.

“ Because you are thinking of the pain in your hand,” said he.

“ That is true,” said Lucy, “ but it is pretty well over now. What did you ask me ?”

“ I asked you what caused that kind of sucking in of your hand.”

She thought for an instant, and answered,

“ I believe it was the pressure of the outer air, which was trying to get in at that hole, to fill the vacuum, and which was prevented by the palm of my hand, which it then drove in as much as it could. Well, now I am sure I have *felt* ‘ the pressure of the viewless air ;’ and now you must let me repeat the line,

‘ The spring and pressure of the viewless air.’ ”

Harry repeated it after her, declaring it was a very pretty line, besides, it had some common sense in it. Lucy had said it quite at the right

time, when it did not interrupt him, or any thing that was going on. He was so much pleased with it, that he begged of her to repeat all those lines again for him; and when they went out to their garden soon afterwards, instead of beginning to dig, he desired her to say the lines once more, for that he must learn them by heart. Thus he learnt from her some of her taste for poetry, while she acquired from him some of his love of science.

In repeating these lines, Lucy observed which of them alluded to the barometer, and which to the air pump. When she had first learned them by rote, barometer and air pump had been so jumbled in her head, that she could not understand them.

“ How up exhausted tubes bright currents flow  
Of liquid silver from the lake below ;  
Weigh the long column of th’ incumbent skies,  
And with the changeful moment fall or rise—”

she now knew described the barometer, and the succeeding lines the air pump :

“ How, as in brazen pumps the pistons move,  
The membrane valve sustains the weight above ;  
Stroke follows stroke, the gelid vapour falls,  
And misty dew-drops dim the crystal walls ;  
Rare and more rare expands the fluid thin,  
And silence dwells with vacancy within.”

While Harry was learning these lines by heart, Lucy stopped as she prompted the couplet concerning “ gelid vapour ” and “ misty dew-drops,”

and objected, "I do not understand about misty dew-drops on the crystal walls. I did not perceive any vapour on the glass bell."

Her brother told her that these lines alluded to a fact which he had not yet mentioned to her, which his father had but very lately told him, and he was not clear enough yet about it to attempt to explain it to her.

Lucy said she was satisfied to wait; that it was best not to know every thing at once, and pleasant to have something to look forward to. But altogether she confessed that, though the air pump was curious and ingenious, to use the air to drive itself out, yet the water pump she thought a much grander, and a much more useful machine. She thought the air pump was not of any use.

Harry smiled, and answered, "So I thought at first. But, my dear, that was owing to my ignorance; and when you know more you will find that the air pump is of great use. There are many experiments in natural history, as papa showed me, that could never have been tried, and discoveries that could never have been made, without it. For instance, to give you a little peep into the matter, we could never, without an air pump, have known that a guinea and a feather would fall to the ground in the same time, if there was no air to resist the fall of either of them."

“A guinea and a feather! A heavy guinea and a light feather! oh, brother!”

“Very true, I assure you; as you will see one of these days.”

“Harry, now I think I recollect I heard this about the guinea and the feather before, or read it somewhere; and something else too about the guinea’s making no more noise than the feather when it falls. You will show me this too, will you?”

“I am not sure that I can, Lucy,” said Harry. “I tried in this air pump, and I did not find it was so. The guinea fell on the metal plate here at the bottom, and this plate touches the outer air, and rings, and makes a noise.”

“I do not clearly understand why it should make a noise when it falls, or why it should not,” said Lucy.

“I cannot explain it yet,” said Harry; “and I must try the experiment about the noise over again, to make myself sure whether I am right or wrong. I am certain that the feather and guinea come to the ground in the same time, for that experiment I have tried often, and it always succeeded.”

“Show it to me now,” said Lucy.

“No, not now. But you shall see all this, and a great deal more in time,” said Harry. “But, Lucy, how could you say that the air pump is of no use? When you know more about it, you will

see how much you were mistaken. You will find that all we know about the specific gravities, the different weights of bodies, and a great many curious facts about sound, and I cannot tell you how many delightful experiments and discoveries about the air that comes out of vegetables, and about the growing of seeds and of plants, and other experiments about different kinds of gases, as they are called—I say, my dear Lucy, as my father told me, none of these could have been known without the air pump. And then as to the gases—Oh, my dear, I cannot explain to you yet of what amazing consequence the gases are.”

Lucy opened her eyes, and stood looking, as if she thought she could never admire enough. After a reverend pause, she simply repeated the word “Gases !”

“My dear, do not ask me about them yet. You are a great, great way yet from the gases. But if you are good I will put you into boiling water to-night at tea, and get you on to steam and the steam engine.”

“Thank you,” said Lucy, without knowing clearly what was to happen to her.

“Now let us finish the new walk to my garden,” said Harry. “But, before we go, I hope you will acknowledge the air pump, besides being very ingenious, is as useful as the water pump at least. Hey, Mrs Lucy, you look as if you were not convinced yet.”

“I must wait till I have seen and till I can understand all these things, before I can decide,” said Lucy.

“Very provokingly prudent and slow all at once,” muttered Harry, striking the stones of the new road with his *pounder*.

“Why, brother, how can I possibly say more, when you tell me I am so far from the gases? and I am sure I did not understand a word you said about specific gravities; as to the experiment about the feather and the guinea, I long to see that, with all my heart; and I dare say I shall like the others about sound, and seeds, and vegetables, particularly. But these are all curious experiments for grand philosophers, with your air pump; they may be useful to your men of science, brother; but what I say is, that the common pump is more useful to common people, every day. And I do say, that I like those machines best which are most useful.”

All the rest Harry heard patiently or passively, as he went on pounding his road; but when she came to the last words, “And I do say, that I like those machines best which are most useful,” he threw down his *pounder*, exclaiming, “You are very ungrateful, Lucy!” and he wiped his forehead, for he was very hot; but, checking himself, he added, “Ungrateful to the air-pump, I mean.”

“My dear, I did not mean to be ungrateful to the air pump,” said Lucy, surprised that he could grow so warm about it. “I did not mean to affront the air pump, or you: I am sure I did not know you cared which I preferred. What can make you care so much about the pumps?”

“I do not know,” said Harry. “But I was vexed because you would not do justice to the air pump, and gave your opinion against it, without knowing *all*. I thought that you were like that foolish woman who said to the great chemist, ‘Of what use is all your chemistry, if it cannot teach you to tell me how to take the iron-moulds out of my gown?’ Lucy, I hope you will never be so foolish.”

“Never, I hope,” said Lucy; “and I hope you do not think I ever shall.”

“No, I hope not,” said Harry. “But now I must say for the air pump, there is a use that may be made of it in common every day, in hot weather, to make something that is exceedingly agreeable.”

“What can it be?” said Lucy.

“Particularly with sweet-meats and creams,” continued Harry. “Very good of pine-apple and pleasant of tea; mamma told me, not bad even of water.”

“Do you mean ice?” said Lucy.

“Yes,” said he, “the air pump can make ice.”

“Oh! Harry, I cannot believe that. How can that possibly be done?”

“Go to ‘Conversations on Chemistry,’ my dear, and you will be answered.”

“Very well, I will go to ‘Conversations on Chemistry,’” said Lucy: “but not till I have dug this bed in my garden, and tied up all my carnations, and fed my white rabbit, and finished drawing the last snake of my head of Medusa, and put by the sulphurs in the cabinet, and practised ‘The Rising of the Lark.’”

“Very little chance indeed, through all that jumble of things, of your remembering Conversations on Chemistry and the air pump,” said Harry

“You shall see,” said Lucy; “I have always a good memory for what I wish to do.”



MAKING ICE.

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“ HARRY, I have done all that I said I would: I have dug the bed in my garden, tied up my carnations, fed my white rabbit, finished my Medusa’s snakes, put the sulphurs into their cabinet, practised my ‘Rising of the Lark,’ and read and understood all that you marked for me in ‘Conversations on Chemistry\*.’ ”

“ Really! you have done a great deal,” said Harry; “ much more than I expected. I thought the white rabbit would have made you forget every thing else. And do you quite understand all you have read ? ”

“ I do,” said Lucy, “ for it is very clear. As I was reading I thought I saw every thing that was described; and, after I had finished, I was more anxious than before to see the experiment you promised to show me. Will you let me see it now, before I forget what I understand, and while my *head is in it*, as you say ? ”

“ I will show it to you as soon as ever I can,” said Harry, “ with my father’s assistance. He says that I must not attempt to try this experi-

\* Eighth edition, vol. i., from page 151 to 160.

ment by ourselves, because sulphuric acid, which must be used in it, is very dangerous to meddle with. If we dropped any of it on our clothes, it would burn holes in them; and, if we were to let a drop fall on ourselves, it would hurt us exceedingly. So take care, Lucy, not to meddle with it."

"I will take great care," said Lucy. "I will look, but not touch."

While Harry went out of the room to his father, who was preparing for their experiment, Lucy talked to her mother about the entertaining account, which she had just been reading, of the method of making ice in India, even in the hottest nights.

"How glad they must be, mamma," said Lucy, "when in the morning they see the ice in the shallow pans, which they leave out of doors during the night! Mamma," continued she, "I think that the Emily and Caroline in this book must have been very happy, seeing all the nice experiments mentioned here, and talking to their mother about them, and learning from her. This Mrs. B. seems to be a very good, kind mother. I should like to know her, if she is really a live person. Is there such a real person as Mrs. B., mamma?"

"Yes, there is, Lucy."

"There is! And are you acquainted with her, mamma?" Lucy asked eagerly.

"I am, my dear."

“You are ! And what sort of a person is she ? Do you like her ? Oh ! yes, mamma, I see by your look before you speak. You like her very much.”

“I do, indeed, Lucy.”

“I am glad she is an acquaintance of yours, mamma. I hope I shall see her some time.”

“She is more than an acquaintance of mine, she is my friend ; and if you deserve it, my dear daughter, I hope that she will some time be yours.”

“Oh, brother ! What do you think mamma has just told me ?” cried Lucy, running to meet Harry, who at this instant opened the door, and came in, followed by his father.

“Oh, papa, do you know—”

“But observing that her father’s hands were full, and that he and Harry were intent upon bringing in the air pump, she wisely ceased her exclamations, and stopped short in what she was going to say.

“Right to be silent, my dear,” said her father, as she stood by without uttering a word, all the time they were preparing to show her the experiment. “It is very troublesome and disagreeable to have little girls, or little anybodies, or great anybodies, talking all the time we are busy preparing experiments.”

“Busy and anxious too, you know, papa ; for some experiments are dangerous,” said Harry.

Lucy had learned, from what she had just read, that sudden evaporation can be caused by taking the pressure of the atmosphere off water, which produces cold sufficient to freeze it even when the outer air is much above the freezing point. A thermometer was near the air pump, and Lucy looked at it, as Harry desired she would. She saw that the mercury stood at 65 degrees, and she felt that the room was warm.

Her father placed under the receiver a large shallow saucer, filled with sulphuric acid, and in it a small cup of water, raised on a little stand, with a thermometer in it, as described in "Conversations on Chemistry."

He asked Lucy if she knew for what purpose the sulphuric acid was put there.

She said that the book had told her, that the use of the sulphuric acid was to attract and absorb the water as it was evaporated.

"And why should it be absorbed?" said her father.

"Because we want to freeze the water," said Lucy.

"True; but you have not explained to me why we desire that the sulphuric acid should absorb this vapour."

"Because, papa, that vapour fills up part of the vacuum, and it must be taken away, and the sulphuric acid does this as it absorbs it."

“She understands it,” said Harry. “Now we may go on—look, Lucy, at what happens—keep your eyes fixed upon the water.”

She did so, and she soon saw little bubbles appearing on its surface.

“It is beginning to do something,” said she; “but it looks more as if it were going to boil than to freeze.”

“You know,” said he, “that before water can freeze it must appear to boil.”

“Yes, *appear*; I understand why you say appear. That was explained to me in the book.”

“Now it begins to freeze,” said Harry, “look at the little spikes of ice.”

Lucy saw this, and said it was very curious; but still she did not look quite so much surprised and pleased as Harry had expected, because, as she said, she saw only such tiny spikes of ice. She had imagined that all the remaining water in the cup would have been turned at once into a solid lump.

Harry had talked to her about pine apple ice, and various other kinds of ice, which were so pleasant to eat in hot weather, and which he boasted that the air pump was so useful in assisting people to make; but, from the tiny spikes she had seen, she could scarcely conceive that a sufficient quantity could be made for this good purpose. Harry asked his mother if she would give them some cream

and some sweetmeat to make sweet ice cream; he wished exceedingly to show Lucy that it could really be done in the air pump. Their kind mother provided them with all that Harry desired; but she doubted that they would be able to succeed, as it was difficult even to freeze water. Harry was determined to try, for he had heard that it was a common practice in London, to make use of an air pump in making ice cream. His father warned him that he was mistaken, but that he might try, and that he would then find out what his mistake had been.

Harry put the cream into a small tea cup, and Lucy mixed with it their raspberry jelly. They put the tea cup into a larger cup filled with water, and this they placed on a little stand, which rested on a saucer, filled with sulphuric acid, within the glass bell of the air pump. It happened, as it too often happens to young experimenters, and to old ones also, that their experiment did not succeed. They could not freeze the cream.

They tried to console themselves by eating the cream and sweetmeat. This was, however, but an imperfect consolation to Harry. The honour of the air pump and his own were at stake, and he recurred to the subject immediately.

“ I suppose my mistake was in putting the cream and sweetmeat into the air pump. I was only told that the air pump was useful in making ice. How

they make the ice cream with it I cannot guess," said Harry.

"I can tell you that," said Lucy, "for I once saw the housekeeper make raspberry ice-cream."

"Have you?" said Harry; "and how did she do it?"

"She put some cream and sweetmeat into a tin cylinder: tin I believe it was, or pewter. And this she surrounded with a great deal of pounded ice and salt. Then she kept turning and turning the cylinder round, with the cream in it, till at last it was all frozen."

"Oh! oh!" said Harry, "then now I see how it is. The air pump produces ice enough to freeze the cream. That must be the way it is useful."

"But how can it produce it in such quantities as would be necessary? It would be a year at the rate I saw it going on, with a little cup full of water," said Lucy.

Harry acknowledged this, and they appealed to their father.

He told them, that, for this purpose, much larger air pumps than they had ever seen would be necessary. That consequently a greater vacuum was produced, and more water frozen.

"Then it is true; Lucy, you see, the air pump does make the ice that makes the ice cream, and it is used for this purpose in London. Is not it, papa?"

“Not in London,” answered their father; “it is too expensive a process to be of much advantage in this country; but I believe it has been found useful in India.”

“In India! There, Lucy, you see how useful it is, and how far its fame goes,” said Harry.

“Did they really send an air pump made in England to India for this purpose?”

“Yes,” said her father. “And, when we go to London, I will show you Mr. Carey’s apparatus for making ice.”

“Oh! thank you, father; and I shall really see it made, not in little spikes, but in quantities,” said Lucy.

“Now, Lucy, you will acknowledge,” said Harry, “that the air pump is useful for common purposes.”

“I will; I do,” said Lucy.

“And you will have much more to acknowledge on this subject by and by,” said her father; “when you see that it is applied to other purposes of common life.”

“Oh! what, father?” cried Harry.

“That I will not tell you now, Harry.



STEAM-ENGINE.  

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IN the evening, before tea-time, Harry and Lucy played at spillikens, and afterwards a game of chess, in which Harry was beaten; because he was thinking of something he was going to tell Lucy about the steam-engine, and he missed seeing a rogue of a knight that had got so close to his king, that he could not stir without being check-mated.

“Now for the steam-engine, which you promised to explain to me,” said Lucy.

Harry was afraid that he could not, and, turning to his father, asked him to explain it. But his father desired that he would first try what *he* could do.

“This will be of service to you, Harry, for you will be then certain whether you comprehend it yourself or not. People are never sure they understand anything perfectly till they have explained it to another. If Lucy is puzzled I will help you out of your difficulty, whatever it may be.”

Harry said he would try, and began with these words:—

“In the first place, a steam-engine is a machine —” There he stopped, and began again with,

“In the first place, Lucy, you must know, that the machine called the steam-engine was invented —” He stopped short again, and a third time he attempted it, but he hesitated, and blushed, and, turning again to his father, he said, “I cannot explain it before you, father. I am so anxious. It is very odd. I am not the least afraid of you, you know; but I feel so ashamed and anxious. I think I should do it a great deal better if you were not by.”

“Very well,” said his father, laughing; “then either you or I must go out of the room it seems. Luckily for you, I am just going into the next room. Is that far enough off? though the folding doors are open, I assure you I shall not hear you.”

“That will do perfectly,” said Harry.

“But what will you do about mamma! She must stay to make tea,” said Lucy. “Look, here is the urn coming in. Had not you better come out into the hall with me, Harry?”

“No, no,” said Harry, “I do not mind mamma; and, now I think of it, I want the urn. Lucy, look at the steam coming from the top of that urn; do you recollect, a great while ago, my father’s holding a cold plate over the steam coming from the urn?”

“Yes,” Lucy said, she remembered it well, though it was a great while ago. She remembered that the cold of the plate had turned the steam into water again,—had condensed it. She recollected the drops on the plate, which afterwards ran into each other, and down into little streams, when the plate was sloped.

“Yes,” interrupted Harry, “you have recollected enough of that; you are clear then that cold can condense steam, that is, can turn it back again into water.”

“Perfectly clear,” said Lucy.

“Now recollect another thing,” said Harry; “which took up most room, the steam when it was steam, or when it was turned into water?”

“It took up much the most room when it was steam,” said Lucy. “I am sure that cloud of steam which you see rising from the tea-urn, and which takes up so much room in the air, might, if you held a cold plate over it this minute, be condensed into a few drops, which would not half fill a tea-spoon.”

“Very true,” said Harry; “now do not think any more about that; but do you recollect our talking, a great while ago, about the tea-kettle’s boiling over, as it is called? and do you remember my saying, that if the top of the tea-kettle was screwed down tight, and if the spout was stopped,

so that no steam could get out, that I thought the tea-kettle would burst?"

"I remember it all," said Lucy; "and papa said, you were very right; and I remember afterwards the bursting and explosion of my chestnuts; and the story papa told us of his pouring the hot lead into the damp elder, to make a pencil; and the fact\* I read about the bursting of a little hollow brass ball, in which there was water that turned to steam, and which caused an explosion, that blew a whole foundry to pieces."

"Then you have some idea of the power of the expansion of steam," said Harry.

"To be sure I have," said Lucy; "I know it is terribly great, bursting and killing people, and tearing away! How frightened I should have been, if I had been papa, when he was a little boy, when the lead bounced up to the top of the ceiling! I am sure I was frightened enough when my own horse chestnuts bounced."

"But if this terribly great power," said Harry, "were carefully used, and cleverly used, it would do, as you shall see, the most surprising and the most useful things; it would raise water high as the house, and higher, from the bottom of the deepest mine: it could raise the weight of this room, and all that is in it, as high as the top of the highest tree, and higher."

\* Scientific Dialogues.

“Oh, brother! brother!” cried Lucy.

“It is quite true; it can do more in an hour than two hundred horses and fourteen hundred men. It can drag loaded waggons full of coal, such as you have seen going step by step, the horses pulling hard—it can pull these waggons up as easily as I can pull your little cart.”

“My dear brother, how can I believe it?” said Lucy.

“It can drive across the sea, against the power of the wind and the tide, a great ship, with all the people in it, and all their horses and carriages, and all that they have in the world.”

“Is it really possible?” said Lucy. “I have heard people talking of steam-boats, and of the working of steam-engines; and I remember papa’s asking a gentleman, who was here the other day, whether his steam-engine was an hundred horse power. But I never knew how this was, nor could I conceive that steam could do all this by itself. Only steam like that?” said she, fixing her eyes upon the steam that still came from the tea-urn.

“Yes, only steam like that,” repeated Harry. “Think what we men can make it do at our bidding.”

“Really and truly, Harry,” said Lucy, “it does more at men’s bidding than any of the genii in the Arabian Tales, more than any of the slaves of

Aladdin's lamp, for the hardest working of them could only be made to carry one house."

"Very true, indeed," said Harry, and for once he was pleased with an allusion.

"But," continued Lucy, "I should be very much afraid of its doing some great mischief some day, like the African magician. Do you remember?"

"But, my dear," interrupted Harry, "do not tell me anything more about the African magician."

"Only this one thing, Harry; if you would let me get it out of my head, I should attend so much better."

"No, my dear Lucy. Is it not very hard upon me, that you are to say everything that comes into your head, and that puts out of mine all that I want to remember about the steam-engine for you?"

"I beg your pardon," said Lucy, "I will not say a word more of the African magician. Go on."

But poor Harry could not go on immediately. "Where was I?" said he to himself. "What was I going to say?" As he spoke he rubbed his forehead first, and then ran his fingers through his hair from the roots upwards, till it was all pushed up, and stood erect, "like quills upon the fretful porcupine."

“ Now I recollect what I was going to say,” cried Harry. “ Look at the tea-urn, Lucy. Ah! but now it is too late; there is not steam enough—it is not strong enough to do what I wanted you to see. But at first, when the water was boiling, and the steam rushing out at top, you might have seen it pushing up the lid of the urn, till the steam got out, then the lid fell, and lay still till more steam was formed, and pushed it up again. I wish you had seen it going up and down.”

“ I have often seen it,” said Lucy, “ and watched it moving; because sometimes I was afraid the top would be quite lifted up, and blown off.”

“ And so it would,” said Harry, “ if it were not for these little holes, look here, through which the steam escapes, and which were made on purpose to let it escape, without blowing off the top, or doing any mischief.”

“ That is very prudent; I am glad the holes are there,” said Lucy.

“ But suppose they were not there,” said Harry, “ and the top left loose as it is now. If the water boiled *well*, as people say, if a great deal of steam came rushing up, and pushing out through this place where the top goes on, you know the top would be lifted up. And suppose I lay on the top this weight,” continued he, taking up from the table a small weight, which was used

for keeping down papers, "and suppose I put a lamp under the urn, so as to keep the water boiling, and sending up fresh steam, what do you think would happen then?"

"I am not sure," said Lucy. "It would either burst the urn, or lift up the top with that weight upon it. It would, I am sure, lift up the top and weight, because that would be the easiest way for the steam to get out."

"To be sure. It would require much less force," said Harry, "to lift this little weight than to burst the urn. The expansive force of steam you know I told you, would lift the house. Now suppose that, instead of that urn, with a little lamp under it, there was a great fire, as large as a kitchen fire and larger, and a great iron boiler, as large as the boiler you have seen in the kitchen and larger, with water boiling in it; and over the mouth of that boiler suppose we put a cylinder like the body of a pump, as large as that in the yard, and closed well round at the place where it is put in, so that the steam of the boiling water can get out no way but up the cylinder."

"Then," said Lucy, "how the steam would rush up through the valve in the piston! What a cloud of steam would come out at the top!"

"Stay, stay, Lucy; I was going to have told you, that in this piston there is to be no valve; it is to be a tight stopper. Now suppose, before I



let the steam in, that I have the piston down at the bottom of the pump."

"Why then, before you let in the steam you must put a great weight to keep the piston down, or it would be thrown up to the ceiling, as the lead in papa's pencil case was."

"And I believe," said Harry, "your great weight would be thrown through the ceiling, and would break it to pieces. Consider, my dear, if the small quantity of water that was in papa's elder pencil case could, when turned into steam, force the lead up to the ceiling, and if the small quantity of water that was left in the little brass ball could burst, and blow up a whole foundry, such a quantity of steam as this would be able to lift up and blow up this room, and all that is in it."

"But if that is your only way of lifting great weights, and of lifting the house, I do not see how it can be useful."

"Patience, Lucy. Suppose that we know beforehand the weight of whatever we wish to lift, we can calculate and lessen the fire, and lessen the steam, till it is just enough, and no more than enough, to lift the weight gently up, to whatever height we please—suppose now to the top of the pump. Then you do no mischief, you see."

"Very well," said Lucy, "if you can calculate exactly, and make no mistake. That is very nice."

"But now suppose you want to do this more

than once; to lift several weights, one after another—could you do it? You have the piston and the weight up at the top, and the steam in the cylinder of the pump.”

“ I do not know,” said Lucy; “ for I dare not take the weight off the piston. I dare not touch it.”

“ I would not advise you to touch it, indeed,” said Harry.

“ Then what can I do?” said Lucy.

“ Think,” said Harry.

“ But the idea of the steam going on, coming up through the pump, frightens me. I will tell you what I would do; I would put out the fire directly, throw water upon it.”

“ Very well thought of,” said Harry, “ but then there is steam in the boiler.”

“ I would throw water into that if I could, but I cannot get at it. I would throw cold water all over the outside, and that would cool the steam.”

“ But still there would be the steam in the body of the pump,” said Harry.

“ And I cannot throw water into it because of the stopper,” said Lucy. “ Well, I will throw cold water over it, all down the sides, and over the piston at top, and cool it, and make it as cold as the plate papa held over the urn, and colder; then it would condense the steam within, and turn it into a very small quantity of water.”

• Then what would happen?" said Harry.

"The piston would fall down—there would be nothing to hold it up. The steam would be all gone."

"And what would there be, or would there be any thing, in the place of the steam?" asked Harry.

"There would be nothing but a little water; there would be a vacuum, all but those drops of water," said Lucy.

"Very well, indeed," said Harry. "Now you have the piston down, how will you raise it again? I want to have another weight brought up."

"Then, you know, I must light the fire, and boil the water again," said Lucy.

"Aye, and wait till the cylinder is heated too; for, till that is heated, it will condense the steam," said Harry.

"Certainly," said Lucy, "you must wait till it is hot."

"But it would be very inconvenient," said Harry, "to wait while you light the fire, and boil the water, and so on. Cannot you find any better way of condensing the steam, without putting out the fire every time?"

Lucy thought for a few moments, and answered, "Perhaps, without putting out the fire, it would do as well if I could but let cold water into the boiler, and into the cylinder of the pump."

"But why into the boiler," said Harry.

“ Because the fresh steam would come up continually if I did not prevent it,” said Lucy.

“ But suppose,” said Harry, “ you have condensed the steam in the cylinder, and you only want the vacuum for an instant or two, just to let the piston fall ; and suppose that for that little time the steam from the boiler could be prevented from coming in ; I need not tell you how, but it can.”

“ Then I need not put out the fire, but I may condense the steam in the cylinder,” said Lucy ; “ that will be much more convenient, because afterwards the steam will be ready to be let in again, under the bottom of the piston, if you want another weight to be sent up. But still I do not know how to get the cold water into the body of the pump, I mean into the cylinder, to condense the steam.”

“ The steam,” said Harry, “ is let off into a separate vessel, called, from its use, a condenser. This vessel is surrounded by cold water, so that the steam is condensed, as soon as it comes into it.”

“ And is this all the steam-engine ?” said Lucy.

“ No, my dear Lucy, it is only the general principle. I cannot explain all to you, I should only puzzle you. There are different sorts of steam-engines. In that invented by Mr. Watt, the expansive force of the steam is used in different

degrees, to raise the piston, and to force it down."

"I did not know that the steam was ever let in above the piston," said Lucy.

"Yes, it is. I did not tell you that at first, lest I should puzzle you, and I will not now tell you exactly how it is done. And there is a great deal more to be explained, about the ways of making the steam-engine raise weights, or water, or work machinery, in different directions. Ours was but an awkward way of raising weights, by putting them on the top of the piston. Suppose you want to raise water from a pond, you must put a beam out from the top of the piston, like a scale beam, and with this you might work the piston of a pump fastened at the other end of this beam."

"Very convenient!" said Lucy, "and very simple."

"There are a great many other contrivances," said Harry, "and ways of making it turn wheels, and pull and push sideways, or in any direction in which you want to have work done, or force applied: but I should tire and puzzle you to death if I were to tell you all at once. Papa took several days to explain to me the parallel motion, and the fly-wheel, and the sun and planet motion, and the excentric."

"Oh, my dear brother!" cried Lucy, stopping her ears, "this would puzzle me to death indeed."

“Therefore, my dear, I tell you, I will not say one word about any of these things to-day, but I will leave your head quite clear, as I hope it is, in the general principle, as papa calls it. And here he comes with his letter in his hand.”

“Mamma is beginning to pour out tea,” said Lucy, “let us go to her.”

“Stay one minute, Lucy,” said Harry. “Now pray, when you are called upon to explain to papa, be quite steady. Do not be a coward, and fancy that you do not know what you do. And do not be too quick either. Above all, do not go the least beyond what you really know. Do not put in any of your ‘*It’s like this*’ or ‘*It’s like that*.’ When you have no more to say, stop.”

“I will,” said Lucy. “I will not say one word more than is necessary, nor make one allusion or quotation. I will be like your own dear Menelaus; I’ll say no more than just the thing I ought.”

STEAM-ENGINE,  

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“Now, papa, will you ask Lucy to explain to you what she knows of the principle of the steam-engine?” said Harry, walking with her up to the tea table, with a composed countenance.

“First, Harry,” said his father, “I must ask your mother to read this letter for me, and I have a great deal to say to her about it.”

Harry sat down with a resigned look, and swallowed tea, and eat bread and butter, without hearing one word of what was going on, till at last his father turned to Lucy, and said, “Now, my dear, I am ready for you and the steam-engine.”

Lucy, who had been listening to the letter declared she was afraid the whole of the steam-engine had gone out of her head.

In astonishment Harry stared at her, and, in a tone of indignation, exclaimed, “Is it possible, Lucy?”

“Stay, do not frighten me,” said Lucy, “and perhaps I may get it back again.”

She did, and she recollected all Harry had said to her; she distinctly said “no more than just the thing she ought.” Her father was doubly pleased by the clearness with which she made her expla-

nation, because it showed that Harry had understood well what had been taught him.

“I promise you both,” said he, “that, the first time I have an opportunity, I will show you a steam-engine.”

Harry was delighted with this promise, and Lucy clapped her hands, and added, “I know, Harry, that the opportunity will come soon.”

Harry was going to ask her how she knew this, but his attention was taken off by his father’s observing to him, that he had done well to refrain from describing to his sister any of the lesser parts of the machinery.

Lucy said, “It was not at all difficult to me, papa, for he brought me up to the steam-engine by degrees, and I was quite surprised when I found I was at it. I did not know what he was about when he began with your cold plate, and the tea urn, and the expansive force of the steam, and the condensing the water ; but I saw plainly afterwards, when I found out where I was. It was just like his way of leading me blindfold on the gravel walk, and taking me to this place and that ; and I do not know where I am, or where he is leading me, till he takes the bandage off my eyes, then I am quite surprised at what I see before me.”

“Ha! ha! Lucy, I thought you could not get through without a simile,” said Harry. But he was well enough pleased with this. His spirits



were so much raised by his father's commendation, and by the promise of seeing a steam-engine, and by Lucy's success and his own, that he could not refrain from going on to tell her the names of the first, second, third, and fourth inventors and improvers of the steam-engine. But he was fortunately stopped by his father's getting up to look for a book, in which, he said, he could find a poetic description of the wonders performed by the expansive force of steam.

"Oh, I know that book," said Lucy; "it is the same, Harry, in which there are the lines on the barometer and air pump."

"The description of the steam-engine," said their father, "begins by doing honour due to him, who

'Bade with cold streams the quick expansion stop,  
And sunk the immense of vapour to a drop.'

Who was that, Lucy?"

"The inventor of the steam-engine, the man who first thought of throwing cold water upon it to condense the steam," said Lucy.

"Savary, or the Marquis of Worcester, I do not know which," said Harry. "You know, father, there have been many disputes for the honour of this great invention."

"Yes, but let these rest for the present, Harry," said his father. "Savary is the person alluded to in these lines."

“Do go on reading, papa,” said Lucy. “I like those lines so much.”

Her father continued:—

“Pressed by the ponderous air, the piston falls,  
Resistless sliding through its iron walls,  
Quick moves the balanc'd beam, of giant birth,  
Wields its large limbs, and, nodding, shakes the earth ;  
The giant power, from earth's remotest caves,  
Lifts with strong arm her dark, reluctant waves,  
Each cavern'd rock and hidden depth explores,  
Drags her dark coals, and digs her shining ores.”

“Yes, I understand,” said Lucy ; “that describes the steam-engine bringing up water from the bottom of mines, and dragging the coal waggons, as Harry told me it could.”

Her father went on reading :—

“Next in close cells of ribbed oak confined,  
Gale after gale he crowds the struggling wind,  
Th' imprisoned storms through brazen nostrils roar,  
Fan the white flame, and fuse the sparkling ore.”

“The great bellows in forges and founderies, which are moved by the steam-engine,” said Harry. “I never should have thought they could have roared so well in poetry. Pray go on, papa.”

“Here high in air the rising stream he pours  
To clay-built cisterns, and to lead-lin'd towers ;  
Fresh through a thousand pipes the waves distils,  
And thirsty cities drink the exuberant rills ;  
There the vast millstone, with inebriate whirl,  
On trembling floors his forceful fingers twirl,  
Whose flinty teeth the golden harvests grind,  
Feast without blood, and nourish human-kind.”

“Do you understand, Lucy?” said Harry “I forget, my dear, whether I told you, that the steam-engine keeps corn mills and all sorts of mills going.”

Lucy nodded. “Do not let us interrupt papa; I will tell when I do not understand,” said Lucy, “but I understand all as far as he has gone.”

“Now his hard hands on Mona’s rifted crest,  
 Bosomed in rock, her azure ores arrest;  
 With iron lips the rapid rollers seize  
 The lengthening bars, in thin expansion squeeze;  
 Descending screws, with ponderous fly-wheels wound  
 The tawny plates, the new medallions round,  
 Hard dies of steel the cupreous circles cramp,  
 And with quick fall his massy hammers stamp;  
 The Harp, the Lily, and the Lion join,  
 And George and Britain guard the sterling coin.”

“Lucy, I am sure you cannot understand this,” said Harry.

“No, I was just going to say so, Harry; I waited only till papa came to a full stop. But I know that Mona means Anglesea.”

Her father said that she was right; that the azure ores allude to copper mines in the Isle of Anglesea, or Mona, which are worked by the steam-engine. *Cupreous* means *of copper*, and the ores of copper being bluish, the poet calls them “Mona’s azure ores.” The succeeding lines describe machinery for coining copper, first rolling out thick bars of it into plates, thin as halfpence, then cutting those plates into circular forms, and stamping them with the arms of Ireland, France,

and England, the harp, the lily, and the lion. All which is done by machinery, without the hands of men, and that machinery is kept at work by the motion and power of a steam-engine.

Harry looked triumphant while his father spoke of these wonders performed by steam. Lucy could not conceive how it could do all this. Her father repeated his promise, that whenever he had an opportunity he would show her how it is done; and Lucy whispered again to Harry, "Very soon, too, perhaps."

"Is there no more, father? Is there nothing about the steam-boat?" asked Harry.

"There is," said his father; "and it is curious, that these lines were written several years before steam-boats had been brought into use; and at a time when it was scarcely believed by any but a few courageously ingenious persons, that the steam-engine could ever be successfully or safely employed in driving forward vessels on the water. This prophecy, at the time it was made, most people thought merely poetical; and instead of expecting that it would be *soon* accomplished, it was thought that it would never be effected:—

'Soon shall thy arm, unconquer'd steam! afar  
Drag the slow barge, or drive the rapid car.'

"The *slow* barge now goes as fast as you please," said Harry. "The *rapid* car is to come; and I dare say that will be accomplished soon, papa, do

not you think it will? And oh, father, read this; here is something about a flying chariot, which we did not hear:

‘Or on wide-waving winds expanded bear  
The flying chariot through the fields of air.’”

His father had purposely omitted to read these, and prudently declined giving his opinion.

Harry became silent and thoughtful for some minutes, but occupied himself with burning a lump of sugar, whose amber drops, as fast as they fell and cooled, he put into Lucy’s mouth. And when the sugar basin was taken from him, he found new recreation for his fingers and thoughts in his mother’s tambour needle, which he pushed and pulled up and down, through silk and through paper, till she took that from his hand, and then he had no resource but to lean with both his elbows on her frame, and to watch her plying the needle. He whispered from time to time—

“Will not you come and play at ‘*Travellers*’ with me?”

But in vain she twitched his elbow, it remained fixed.

“My mother’s work is like a chain,” said Harry; “link within link—loop within loop.”

“Yes,” said Lucy, “it is called chain-stitch.”

He watched the lengthening chain, which, with the quick noise of successful pricks, advanced towards him, forming a line from one end of the

frame to the other, which was accomplished in two minutes counted by the watch. Then scallops and leaves, pointed and round, grew under her hand. Nothing too difficult for the dexterous hooked needle.

“It goes on so easily,” said Harry, “it seems to do it of itself.”

“And do you think you could do it, Harry, as mamma does? Mamma, pray let him have the needle and try.”

Harry had little doubt that he should succeed, if he might be allowed to try, because he had most carefully observed all his mother did; he had watched her hand under the frame, and had seen, as he said, how, by a little quick motion, she hung the cotton or silk, whichever it was, over the hook of the needle, and then pulled both up together through the muslin, exactly through the middle of the last link, and then dragged on a new loop, with a little twitch and twist; and down again with the needle.

“Well observed, and accurately described, I grant,” said his mother; “you are perfect in the theory, but now for the practice.”

She put the tambour needle into his hand, the feeling of which he liked particularly, because its ivory handle was as large as a pencil case, and something fit for a man to hold.

“Now we shall see how the man will work

tambour work," said Lucy. "Aye, down goes the needle, pop through the muslin, easily enough; but now get it up again, and the silk with it, if you please and can."

Harry turned the ivory handle to this side and to that, and leaned it this way and that way, and twisted and double twisted the silk on the hook beneath; and twitched, and plucked, and pulled in vain, and came to "Pooh!" and "Pshaw!" and "Do not look at me, pray. I cannot do it if you look at me."

"Nor if we do not look at you," said Lucy.

"I have done it!" said he, dragging up the needle by main force, and making a hole in the muslin through which he hauled it.

"Oh, Harry! what a hole!"

"I do not know how it happened," said Harry, "but the needle is up at any rate, and the loop with it; and I have one link of the chain, what you call one stitch, and now for the next, which you see I will do better."

He tried again, but the hole made it impossible; he pulled out his first, his only stitch, and tried again in a fresh corner. Nothing ever did try his patience, or, as he thought, nothing ever did try human patience so much. But, by taking thought, he did get the needle and the loop safe through this time without tearing the muslin. He persevered, and in a quarter of an hour had really

worked a quarter of an inch of chain, all crooked, dragged out, short and long links of various sizes. Sad chain-stitch, as Lucy called it, but still she could not deny that he had done it. His fingers were so hot that he spread them out to cool, and groaned, and took breath, as his father said a coal porter might do, after setting down the heaviest load.

His father next took the needle in hand, with a theory as perfect, with somewhat more diffidence, but with little better success. There was a knack in it, which could be learned only by practice. But the gentlemen talked very learnedly to each other about it, and agreed that their perfect theory had helped, would help, or should have helped, them very much.

“But how wonderfully quickly my mother does it,” said Harry. “Do it again, mamma, pray. How can you go on so quickly with the work?”

“You think I go on quickly,” said his mother, “but all that I could do in a day could be done by a machine, Harry, in an hour. And by what machine, do you think? By your dear steam-engine! This is a use for it of which you never thought.”

“Is it possible?” cried Harry.

“Can these *ins* and *outs*, and all this delicate work, and these pointed leaves, be all done by a steam-engine?” said Lucy.



“A huge steam-engine!” said Harry.

“Mamma, how I should like to see it at work, doing the tambour work,” said Lucy.

“Perhaps I shall be able to show it to you, my dear,” said their father.

“And soon,” whispered Lucy to her brother.

“What can you mean?” said Harry. “why do you say, *and soon*, over and over again.”

“My dear, did not you hear the letter, and all papa and mamma were saying about it?” said Lucy.

“Not I,” said Harry.

“You were sitting at the tea-table all the time, beside me,” said Lucy.

“Very likely,” said Harry; “I did not hear a word that was said.”

“What could you be thinking of?” said Lucy.

“I do not know,” answered Harry. “Of a bell crank, I believe. When I saw mamma pull the bell cord, I thought I would show you the bell crank in the passage to-morrow, and explain by that the crank motion in the steam-engine.”

“How full your head must be of this steam-engine,” said Lucy.

“And of you, Lucy, my dear; I was thinking of something to show to you.”

“Thank you,” said Lucy; “then I will now tell you all that I heard, that you did not hear. The letter was papa’s answer to Sir Something

Somebody, the man, the gentleman, husband to the lady who told of the shipwreck, when she called here the morning that I spotted my gown with the dirty water from the pump and pond."

"But never mind that now," said Harry; "get on, my dear, I want to hear what is to come."

"Papa's letter was to thank that gentleman for the trouble he has taken in looking for a house somewhere, a great way off, by the sea-shore."

"And why did papa thank him for that?" said Harry.

"My dear Harry, you are so slow in understanding," said Lucy. "The house is to be for papa and mamma; and if there is but room enough in it for us, we are to go with them."

"You do not say so!" cried Harry, starting upright with joy.

"I do say so. I heard it with these ears, and very good ears they are," said Lucy; "and papa told me I might hear. His letter said, towards the end of it, 'I hope there may be two little rooms for Harry and Lucy, their mother and I wish to have them with us.'"

"How kind! Oh! any sort of little rooms—any little dens would do," said Harry. "I could sleep in a drawer—in a nutshell! Could not you, Lucy?"

"To be sure," said Lucy. "But if they cannot in any way find room for us, we are to be left with my uncle."

“Oh!” cried Harry, uttering something like a groan, “I hope we shall not be left with my uncle, though in general I like to be with him very much; but I never went a journey, a long journey, and with papa and mamma! Lucy, think how delightful it would be! to see mountains, and go up them with my portable barometer.”

“And to be by the sea-side,” said Lucy. “I never saw the sea, and I shall pick up shells by the sea-shore—beautiful shells, and sea-weed, and sea-urchins; and we shall live in a cottage. Oh! think of living in a cottage!”

“And we shall see a steam-boat, and a steam-engine,” cried Harry; “now I understand it all. But remember, it is not certain yet that we are to go, Lucy. I will not think of it any more, lest we should be disappointed at last.”

PACKING UP.

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“Joy! joy! joy! for you, Harry; joy for both of us!” cried Lucy. “The great black trunk, and the little black trunk, and the seat-boxes, and the carpet-bag, are coming down from the garret to mamma’s dressing-room. Packing up is beginning, and we are to go.”

“We! But are you certain, Lucy? How do you know?” said Harry; “I should not like to be disappointed, my dear.”

“Who would?” said Lucy. “But no danger, my dear Harry; I heard the answer to papa’s letter, and it says that there is room for us. Only, that one of us must be put in a very little closet, which can just hold a bed and a chair.”

“I do not care how small it is, if I can but be crammed into it,” cried Harry.

“Nor do I,” said Lucy; “I can sleep on a sofa, or anywhere, so that we may both go.”

“If we do not both go, there will be no joy,” said Harry.

“But I tell you we shall both go. Mamma says she can manage it. They are to set out the day after to-morrow, at six o’clock in the morning.

And I asked mamma," continued Lucy, "if I might pack up your things and mine to-day, in the little black trunk. She says I may, if I can; only she is afraid I cannot do it well enough; but I think I can. Bring me directly, Harry, to the dressing-room, all the things you want to take with you, and I will get all mine in a minute."

Presently two great heaps appeared on the dressing-room floor.

"There are all my goods," said Harry, pointing to one heap. "All these must go."

"And here are mine; I hope they will all go in," said Lucy, looking doubtfully at the little black trunk, which stood between them.

Harry, pressing his hand down on Lucy's heap observed, that "they could be squeezed almost to nothing. Cram my things in any way," said he, "I do not care how, so that they go—only make haste—I will go and finish my Latin lessons, and be back by the time you are ready to lock the trunk. Ram my things in any way, my dear," repeated he, as he left the room.

"Mamma is to see how the trunk is packed, when it is finished," said Lucy, "and I must do it well."

She packed, and packed, and squeezed, and crammed, and rammed, but in vain; she could not get in above half of these things.

Then she took out of the trunk all she had put

in, and by her mother's advice began to sort her brother's and her own into two classes, of *necessaries*, and *unnecessaries*. By this operation, her brother's heap was diminished above two-thirds, and her own nearly half. When Harry returned, he was not at all contented with her arrangement; and, to satisfy him, she gave up several of her books, and reduced her portion to exactly the same size as his. Harry left her to pack the trunk: and this time, having listened to her mother's advice, to lay each thing, as she put it in, as flat as possible, and to leave no holes or hollows, she succeeded in putting in all things necessary. There was one luxury of her own, which she much desired to carry. It was a paste-board tray, that was made for holding shells. She emptied out all its contents, that she might fill it with a new collection from the sea-shore. To her great satisfaction, there appeared just room for it, at the top, in the arched lid of the trunk.

Her mother was called to see how easily it locked, and she examined the packing, and pronounced, that it was as well done as could be expected from so young a packer. She ran to report her success to Harry, and to summon him to see how nicely her shell tray lay at the top of all the things, fitting under the arched roof of the trunk. She met him coming up stairs with a

huge book, as she thought, under his arm; he asked eagerly if she had finished packing the trunk.

“Quite finished,” said she; “come and look at it, and you shall lock it yourself.”

Harry looked disappointed, and said, that he was very sorry the trunk was quite full, because he had found something else to put in, which he wished particularly to carry with him, and his father had just told him that it must not go loose in the carriage.

“What is it?” said Lucy: “fetch it; if it is not very large, perhaps I can squeeze it in.”

Harry, half ashamed to ask the question, said, “Could you get in what I have here under my arm?”

“This immense quarto book, Harry! Impossible!” cried Lucy. “It is as large as half the whole trunk.”

“It is only a false book, my dear,” said Harry.

“False or true, that does not make it less,” said Lucy.

“But, as it opens,” said Harry, “and has an almost empty inside, it will hold a great quantity. It will take up scarcely any room in the trunk, only the thickness of its own sides, and they are of very thin wood covered with paper. Do, my dear Lucy, try if you can get it in. It is a camera

obscura, which my uncle has just given to me."

"Indeed!" said Lucy. "Well, my dear, I will try my very best."

But, on opening the false book, she observed that it was not nearly empty; that there was some apparatus withinside of it, which took up a great deal of room. She saw especially a glass, which she was afraid would be broken, if she put any thing withinside. He urged her, however, to try. If it were packed with soft things, such as her frocks, all would be safe. "If we can but carry the camera obscura with us," said he, "when we get to any pretty country, and to the cottage by the sea-side, we shall see such beautiful landscapes in it, and the boats and ships sailing. Oh! do Lucy, contrive to carry it."

"I will give up my shell tray," cried Lucy, "and then I can make room for it perhaps."

"There is a dear good girl," said Harry.

She ran, and he followed her to the trunk. He saw how nicely the tray fitted, and he saw her take it out, and put it quite away; he heard a little sigh as she locked the closet door upon it, after putting it out of sight.

"My dear Lucy," said he, "I cannot bear that you should give up your tray; I dare say you wish to carry that and your shells, as much as I wish for my camera obscura"



“Never mind,” said Lucy.

“But I do mind, and the more because you do not,” said Harry.

“But I will tell you why you need not care so much, Harry,” said Lucy; “I can make another tray of pasteboard easily, when we get to our journey’s end, and that will be time enough for my shells at the sea-shore; but you, Harry, could not make a camera obscura.”

“Very true,” said Harry; “thank you. But you have all to unpack, which you had packed so neatly.”

“Never mind,” repeated Lucy, “if I can but get it in.”

“You need not unpack to the bottom: stop, my dear,” said Harry. “The camera obscura is only about one-third of the depth of the trunk.”

In it went, and there was a little space at its ends, and beyond its breadth, into which things could be crammed, and should be crammed, as Harry observed, to keep it tight. The greatest trial of Lucy’s patience was his standing by all the time she was repacking, advising all the while, and saying, as she put in each thing, “That will not go there,” or “This would fit better,” &c. After she had, to the best of her skill, repacked the trunk, there remained on the floor a new jacket and trowsers of Harry’s. The jacket, too, was

covered in front with innumerable hard sugar-loaved shaped buttons, which took up a terrible quantity of room, and which could not be compressed. Harry would have found an easy remedy, by leaving jacket and trowsers and all behind. He thought he could do perfectly well without them. So did not his mother; upon appeal to her, she decided that they must go. What was to be done? Harry, though it would give Lucy a great deal of trouble, thought he saw how it could be managed.

“I do not mind the trouble,” said Lucy, “if I can succeed at last; but I think it is really downright impossible to get more into that trunk, without breaking the hinges in squeezing it down.”

Harry suggested, that if Lucy would unpack the whole trunk, and put the camera obscura at the bottom, perhaps she could get in more, because his jacket, with its hard buttons, might then lie at the top, as her tray had lain, under the curve of the top of the trunk: by having the flat box uppermost, some of that space he thought was lost.

Lucy was not quite clear that he was right; but, however, she, in a most obliging manner, began to unpack the trunk again, and said she would try it *his way*.

All of any age, who have a good opinion of

their own powers of packing—and who has not?—will give Lucy more credit for this than for all the rest. She gave up her own opinion, and repacked, upon her brother's suggestion, with as much zeal and alacrity as if it had been an idea of her own. We are happy to state, that this time she succeeded in putting in what was required, camera obscura, jacket, trowsers, and all, to Harry's joy and admiration.

Her mother was pleased.

“My dear little girl,” said she, “I am glad to see, not only that you are good-natured to your brother, of that I did not doubt; but that you are good-humoured too. Good temper is necessary, even to the most good-natured people. I have often seen good-natured people more ready to make great sacrifices than little ones for their friends; but the little ones are most frequently wanted, especially from women, almost every day of their lives. And if they make these in a good-humoured, obliging manner, as you, Lucy, did just now, they will be beloved, and, as far as they can, will make the friends they live with happy.”

“Yes, mamma,” said Lucy, “as you do. You came into my head when I was unpacking the trunk for Harry. I recollected your unpacking the great trunk one night at Coventry, when the maid was out, and you were tired to death; and

aunt Pierrepont wanted something, which she said was at the bottom of the trunk: and it was not there after all. Mamma, I recollect another thing: one day, when you gave up going to Warwick Castle, which I know you wished very much to see. Well, mamma, on this journey, which we are going to take, you shall see that, if I have any trials, I will be as good—I mean in proportion,” said Lucy.

Harry at this moment returned to the room with their hygrometer, and its register, in his hand; he told Lucy, that he thought it would be useless for them to keep the register while they were travelling, as they should change every day to different parts of England, and it was a register of the weather in one place that was required. Lucy was glad he had found out that it would be useless: she was sure that it would have been impossible for them to keep it, while on their journey; and she felt relieved from a great responsibility, when Harry determined to leave it with their uncle, till their return. Lucy further observed, that it would also be impossible, she feared, to go on regularly with Harry in his course of scientific lessons, for which she was really sorry, though the pleasures of travelling, she acknowledged, might make up for this interruption.

“Yes,” said Harry, “that is true; we must

give up our regular lessons till we come back; but, as papa has just been telling me, it will do us both a great deal of good, and me in particular, to see new things."

"Delightful!" said Lucy; "and thank you, papa, and thank you, mamma, for thinking of such a pleasant way of doing us good."

## COTTON MANUFACTORY

AT six o'clock in the morning, Harry and Lucy were seated opposite to their father and mother, in an open carriage; bags, books, parcels, nicely packed in, and Harry's portable barometer snug beside him. "Drive on."

The young travellers stood holding *by something* no doubt, according to the ever repeated and never to be too often repeated counsel. They looked from side to side as they passed, bidding good-bye to each well known object, half sorry to leave home, yet glad to go on to something new. It was a fine morning, the sun shining, the air fresh, and

“—————Herb, tree, fruit, and flower,  
Glistening with dew.”

Their way led through a lane, the hedges on each side full of honey-suckles, with white and pink bind-weed straggling above, about, and underneath. The ground under the hedges was covered with wild flowers of many colours; abundance of that most delicate weed, if weed it should be called, which paints the banks with blue, well known to all the world by one name or other; to

the unlearned as speedwell, to the learned as *veronica chamædrys*; there was also abundance of that erect plant, with its spire of crimson bells, spotted or plain, by peasants *fox-glove*, by botanists *digitalis* called, valued by the old as a cure for the dropsy, and loved by the young, for the loud pop! pop! pop! which in skilful hands can be made by its flowers. Harry asked Lucy if she knew why the fox-glove is called digitalis.

“No,” said Lucy, “why?”

“Because *digitale* is the Latin for a finger of a glove,” said Harry.

“And the shape of these bells is very like the finger of a glove,” said Lucy; “but why *fox-glove*? foxes do not wear gloves.”

Their father said, that perhaps it might have been called so from growing in the haunts of foxes.

When they came to the end of the lane, and the road opened to the view of freshly mown meadows, and extensive corn fields, Lucy exclaimed,

“Look! look! Harry, at the gossamer glittering in the sun, all over that field, as far as we can see. Do you see it waving up and down with every breath of wind. Pray, mamma, look at this immense cobweb net, all spangled with dew. Is it not beautiful, most beautiful, Harry?”

Harry answered, “Yes;” but it was a yes

uttered in a cold tone, which did not satisfy Lucy. Yet he looked at the gossamer earnestly. But he was always more curious about the causes of whatever he saw, than pleased by their appearance. While Lucy had been admiring the glittering, floating, waving net, Harry had been considering how, or by what this net was made. Lucy said, that in her favourite book of insects\*, and in other books, she had read something about gossamer. He begged she would tell him all she knew of it directly.

And as fast as she could she told him, that all these shining threads are made by a very small insect, the garden spider, who, like other spiders, can throw out from its body a sort of glutinous substance, which hardens in the air. Some say, that the spider leaves the threads behind him, as he darts through the air in search of food. Others say, that he has the power of throwing it out before him, and that it catches upon the blades of grass, or on the rough edges of leaves and bushes, and then, being pulled tight by the animal, forms as it were a bridge, or road in the air, for him to pass from place to place. He has been called by some people the flying spider, and the threads are called air threads, and sometimes these are seen floating over head, and sometimes they are borne down by the weight of the dew,

\* Dialogues on Entomology. Rees' Cyclopaedia.



and then caught on the bushes. Harry asked if Lucy ever saw the spider throw out or leave behind him these air threads ?

She had not seen it herself, but she remembered, that one man in particular, who wrote about the flying spider, declared that he one day *saw* him throw out from his body this substance, and saw him afterwards mount and ride away upon it.

Exact Harry was preparing to question whether the flying spider flew, or crept, or rode, walked or darted upon the gossamer, or whether he moved of his own free will, or was blown, or borne away by the wind. But Lucy, too quick for his questions, hastened to tell him something more, that she had read of another insect, called the silk spider, who spins silk which is finer than that of the silk-worm. A pair of stockings were actually made of the spider-silk. They were presented, as Lucy assured him, to the French Academy of Sciences, and were much admired. Harry's attention became more respectful, when he heard of the Academy of Sciences.

“ I was thinking,” said he, “ that great use might be made of all that gossamer, if it could be spun and woven.”

“ That has been thought of often,” said Lucy ; “ people, at the time the stockings were made, hoped that the spider would do as well as the silk-worm ; and they set the spiders at work in

paper cases made on purpose, but after they had been kept many months spinning in their paper cells, their work was measured, and it was found, that nearly three hundred of the hardest working spiders cannot produce as much silk in the same time as one good active silk-worm."

Still Harry contended, that, since there are so many spiders, the great numbers might make up for the little they do; and as we have them always ready, how much better it would be to set them properly to work, than to brush them and their cobwebs away, or to crush them to death.

To this Lucy replied, that the common house spider, who is, or ought to be brushed away, is not the silk spinner; that the silk spinners were not as common as Harry imagined. "Besides, many faults," continued she, "are found with their way of working; they break their threads, or spin them only in short pieces, so that their silk cannot be wound, it can only be spun, and the reeling takes off its lustre. This want of lustre was complained of in the famous pair of spider-silk stockings presented to the French Academy. On the contrary, the silk-worm spins her silk without breaking; she winds it round and round into cocoons, which can be easily unwound by a careful person. What length, Harry, do you think the silk-worm can spin without breaking?"

Harry was no judge of spinning; but since he

must guess, he would say about as long as the field over which the gossamer spread—perhaps about a quarter of a mile.

He did not think it possible, but he said it on purpose to guess something provokingly beyond what he supposed any silk-worm could do.

“A quarter of a mile!” repeated Lucy, “that is a good large guess; but you must know, that a silk-worm can spin without breaking as much as when unwound is six miles long! and, if she is not lazy, can do this in nine days! Believe it or not, Harry, as you please; but I assure you it is true. And what spider ever did as much?”

Harry looked as if he wished to urge something more in favour of the spiders, but had nothing else to say, except that still he did not doubt that some way would be invented of making them useful.

“Oh! my dear,” exclaimed Lucy, “I forget my very best argument; spiders can never work together, like good silk-worms, because they quarrel and fight, and eat up one another. My insect book says, that, of I do not know how many, above forty or fifty, that were shut up together in one room, with plenty of flies and pith of quills, and all the delicacies they like, only two of them were, at the end of some days, found alive; and you know it would be impossible to give each of them a separate house; so there is an end of the matter.”

“An end of the matter indeed!” said Harry; “I should never have thought of having any thing to do with them, if you had told me at first that they eat one another. Well, Lucy,” continued Harry, “thanks to you and your insect books, we have had a great deal of diversion out of that field of gossamer.”

“I feel much more pleasure in looking at things,” said Lucy, “when I know something about them, even if it is ever so little.”

“And then there is the hope of *the grand thing* that we are to see by and by,” said Harry. “Papa, when do you think we shall see a steam-engine?”

“Very soon, my dear,” said his father. “In the town where we are to breakfast, I hope to be able to show you the grand thing, as you call it, Harry.”

“To day! this morning!” exclaimed Lucy.

Harry, in grave delight, rose from his seat to return his very best thanks; and, in an uncommonly emphatic tone, began with—

“I am *very* much obliged to you *indeed*, father.”

But while he was pronouncing this in his sober manner, a branch of a tree under which they were going caught his hat, and carried it off. A little thing could make Lucy laugh before breakfast, when she was weak and hungry; and long after the hat had been regained and replaced,

and after the accident was forgotten by their father and mother, who were quietly reading, Lucy shook with unextinguishable laughter, even till they came in sight of the town where they were to breakfast.

After breakfast they walked with their father and mother through the town, to the place where they were to see a steam-engine. A variety of objects caught Lucy's attention as they walked through the busy streets; but Harry was so intent upon what he expected to see at the end of his walk, that he did not look either to the right or the left as he passed.

Much as his expectations had been raised, he was not disappointed when he came to the reality. The ease and silence with which the huge beam of the steam-engine moved up and down, struck him with admiration, and he stood for some time satisfied with watching its uniform motion. Next, he enjoyed the pleasure of recognizing each part of the great machinery that he had seen in the engravings which he had studied, and of which he had understood the descriptions.

Lucy could not immediately comprehend what she saw; she could not extend her ideas from the small scale of the engravings to the great size of the machine, which she now beheld. Another difficulty occurred: she could not at one view

take in all the parts : she did not know where to look for the boiler and the cylinder, and all the innumerable small pipes puzzled her. However, with her father's assistance, she by degrees made out the principal parts, as they were seen in different stages of the building, for all could not be seen at once.

Good-natured Harry delayed to gratify his own curiosity till Lucy was quite clear in every thing she wished to understand : then he began to question his father. He wanted to know what work this steam-engine was doing. He heard some sounds, like the working of machinery, and he wished to see what was doing. The guide, who had admitted them, now threw open a door, and they saw a very large apartment, full of whirling, whirring machinery, rows of spindles full of cotton, like the spindles of a spinning-wheel, standing upright in frames, which reached nearly across the room. Each spindle being supplied by a long line of untwisted cotton, from spools, or bobbins, above. Between each row stood a woman, or child, watching the work, and keeping the machinery clean.

“ This is one of Arkwright's cotton mills,” said the guide. “ All this machinery is kept at work by this steam-engine ; and two other rooms full of cotton-frames, which you may see, if you please, above and below stairs.”

Lucy uttered an exclamation of surprise. Harry was silent with admiration. Turning back towards the steam-engine, he looked about to find where and how the motion was communicated from the engine to the spinning machinery. His father, who guessed what he was looking for, showed him where the shaft was carried through the wall.

Harry had once seen a cotton manufactory, long ago ; but he had only a confused remembrance of whirling spools, and noise, and dust. Here, as he observed, there was scarcely any dust, and but little noise. He was eager to examine and anxious to understand all he saw ; but while he was watching them, the quick motion of the spinning spindles suddenly ceased, and, looking back to the steam-engine, he saw the huge beam descending, with a soft, seemingly expiring motion.

“What is the matter?” cried Harry.

“Nothing, master,” answered the guide, smiling at his alarm. “Nothing, but that it is our dinner time. We stop the engine, and all the machines leave off working for an hour, till we come back and set the engine going again.”

“And is it possible that the steam-engine, and all these machines, can be stopped so soon and so easily?” cried Harry.

The man, pleased by the great interest which he saw that Harry felt, showed him how the whole

was stopped, by closing the valves of the cylinder, and how the steam was let off, after the engine had been stopped.

The women and children were now clearing out of the large room, to go to their dinners, and in a few minutes the apartment was emptied of human creatures, and all was rest and silence. Harry looked blank. He was afraid that he should not see, hear, or learn anything more; and he told Lucy he thought it very unlucky that they had come at the workmen's hour of dinner. But, on the contrary, this proved a happy circumstance; for their father asked and obtained permission to stay during this quiet hour in the cotton mill, and he made use of this time to explain it, and to give them some account of the beginning and progress of the invention, and of its improvement.

“Probably all spinning,” said he, “was originally done, as it still is in the East, and in some of the southern parts of Europe, by holding in the left hand something like a distaff, with the material to be spun wrapped round it. With the right hand the spinner draws out the fibres of this material, whatever it may be, from the distaff, as in common spinning, and they are twisted by a spool or spindle, hanging at the end of the thread, the spool being previously twirled by the finger and thumb. When the motion ceases or diminishes, so as not to be sufficient to twist the thread, what is spun is



wound upon the spool, and the twirling is renewed. This is a simple but tedious mode of spinning. By degrees it was improved, and that ingenious contrivance, the spinning-wheel, such as that with which you are well acquainted, Lucy, was brought into use in England for spinning flax. For spinning wool, you know, a different sort of machine is used."

"Yes," said Lucy, "I recollect the large high wheel, with which I saw a woman spinning wool."

"Now let us go on to the spinning of cotton," said her father, "and the machinery for that purpose. To understand and follow the history of any invention, the first thing necessary is to have a clear idea of what is required to be done, and of the difficulties that are to be conquered. When cotton is taken out of the bale or large parcel in which it is brought from the Indies, it is generally in hard lumps, sometimes stringy. To prepare it for carding, it is beaten with sticks to loosen it, otherwise it would break or spoil the teeth of the cards. It is then carded, the sole object of which operation is to separate all the fibres from each other: cards, something like those you have seen used in carding common wool, are employed for this purpose. The cotton is taken from the card in the form of a roll or *tail*, of about a foot long. Formerly, in the old way of spinning, the next operation was to attach the end of this roll to a

wooden spindle, placed horizontally, which could be turned round by a large wheel. The spinner gave the wheel a twirl, and immediately carrying back her hand, in which she held the other end of the roll, the cotton was lengthened, suppose from one foot to five—and at the same time it was twisted; the direction in which the hand moved had always a certain inclination to the spindle, so that the thread might slip off, over the end of the spindle, at every revolution. By this means it is twisted.”

“ Yes,” said Lucy, “ I understand this : I have seen it in spinning common wool.”

“ Very well, this is called *long-wheel spinning*,” continued her father. “ But it occurred to a poor weaver, of the name of Hargreave, that he could improve this method. As but little strength was employed in drawing out the cotton thread, or in turning the spindle which twisted it, he perceived, that if one woman had ten pair of hands and ten spindles, and could move them at once in the proper direction in drawing out the cotton thread, she could spin ten times as much in the same time.”

“ Papa,” interrupted Lucy, “ if the woman had had a hundred spindles, and a hundred hands, like Briareus, she might have spun a hundred times as much.”

“ Not unless she had known how to use her

hundred hands," said her father ; " hands without head would do little. But now, without talking of Briareus, how do you think one head contrived to supply the place of many hands? Hargreave's difficulty was to hold fast and draw out many threads at once, keeping them separate, and pulling them evenly, while the spindles were twisting them. To accomplish this purpose he took two slips of wood, and cut their edges so that they could lie close together."

" Like the edges of a parallel ruler," said Lucy.

" Yes," said her father. " And between the edges of these he held fast the ends of the several rolls of cotton wool, which were to be drawn out and twisted : the other ends of the rolls, of course, you know, were fastened on the spindles, one on each ; and after they had been drawn out and twisted, the motion of the spindles continuing, the thread was wound round upon them. Now suppose the spindles to be set in motion, and that while they are turning he draws his ruler back, then you see each roll of cotton would be drawn out and twisted at once, as if each were spun by a separate hand."

" I see," said Lucy ; " at least I understand."

" There are some contrivances necessary in doing this, of which I will not describe to you all the particulars, lest I should puzzle you," added her father.

“Thank you, papa,” said Lucy. “But how did the man set the spindles in motion? You said, suppose they were turning, but you did not tell us how.”

“He placed the spindles perpendicularly, side by side, in a row—eight, I think, he tried at first; and he set them in motion by means of the large wheel, or *long* wheel, as they call it, which his wife used in spinning wool, so that they should all move at once. The wheel had a handle, which was turned by his wife, whilst the ruler, which held the cotton rovings, was drawn back, and they were, as he had expected, pulled out and twisted at the same time.”

“How happy he must have been,” cried Harry, “when he first saw it *do!*—when he saw the eight threads drawn out, and the spindles spinning them all at once! How I should like to have been him at that instant!”

“I should have liked to have been in his wife’s place at that instant,” said Lucy. “How happy she must have been, and his children, if they were standing by looking at it! So, it succeeded perfectly?”

“Not so fast, Lucy, my dear; it succeeded for so much, but far from perfectly,” said her father. “His first was but a very rude machine, and he had much difficulty in bringing it to a state fit for working. Then he advanced from

eight to ten, twenty, eighty spindles, and he improved his machine so that it was brought into common use, and he called it a Spinning Jenny."

"A Spinning Jenny! Very right!" cried Lucy. "I suppose his wife's name was Jenny. I hope he made a great deal of money, poor man, to support his family."

"I wonder how he came first to think of this invention," said Harry.

"It is said," answered his father, "but I am not sure that it is true, that the first idea of it was suggested to Hargreave by an accident: a number of young people were one day assembled at his house, at the hour usually allotted for dinner. They were at play, and they by chance overturned the wheel at which Hargreave's wife was spinning wool. The thread remained in her hand, and the spindle was then perpendicular, and the wheel horizontal. The wheel being prevented, by the framework, from touching the ground, it continued to turn round with the motion which had been given to it, and kept the spindle in motion. Hargreave's attention was fixed upon it, and it is said that he uttered exclamations of delight, and again and again set the wheel in motion while it lay on the floor, and stood looking at it a long time, the bystanders thinking that he did so only from idleness."

"Aye, but he was not idle," said Harry; "he

was at work, inventing, at that moment ; but how did the overturning of the wheel help him ?”

“ Of that part of the story I am not clear,” answered Harry’s father. “ It is said, that Hargreave had made attempts to spin with two spindles, with the common wheel for spinning wool, and that he had tried to use his left hand as well as his right, in drawing out the thread, but that he had always found this attempt ineffectual, on account of the horizontal position of the spindles ; but when he observed them standing perpendicularly in the overturned wheel, he saw this difficulty obviated, and he thought of so placing his spindles.”

“ So then,” cried Lucy, “ his invention was made by accident, by the lucky accident of the overturning that spinning wheel. How often and how many inventions are made by accident !”

“ No,” said her father ; “ inventions are never made by accident. To invent is to combine, or put things together for a particular purpose. This, which requires thought, cannot be done by mere chance ; though accident may, and often does suggest the first hint of an invention to an observing mind, or to a mind intent upon accomplishing a particular purpose, and discovers the means that may be used ; as in this instance was the case with Hargreave. How many people have seen spinning wheels overturned, without ever invent-

ing a spinning jenny. But now let me go on to tell you the next improvement that was made in cotton spinning."

"What! did not the spinning jennies do it all perfectly?" said Lucy.

"No, no, Lucy," said her father; "you must not be in such a hurry, we cannot come to perfection so soon. The spinning jennies did only part of what was wanted. The cotton-thread spun by the jenny was found to be rough, spongy, and weak. It could be used only for the wool in weaving cotton, the warp could not be made of it. The warp was then made of linen-threads, which were strong and smooth."

"From what did this defect in the cotton spun by the spinning jenny arise?"

"From the fibres of the cotton not being laid smooth and parallel to each other, while it was drawn out and twisting. In spinning by hand, Lucy, you recollect seeing the spinner not only draw the thread out, but press and move it at the same time, between her finger and thumb. This smoothed the fibres of the cotton, and kept them parallel with each other. Now this was wanting in the spinning jenny. The motion of the hand in drawing out the thread was well imitated by the rulers or clasps, which holding it fast when drawn back, answered the same purpose; but the motion of the spinner's finger and thumb,

and the effect produced by it, was to be supplied."

"How did Hargreave do that?" said Harry.

"He did not do it," answered Harry's father; "it was accomplished by another person, Mr. Arkwright, who, like Hargreave, was originally a poor and illiterate man, but who had the habit of observation, and the power of invention."

"Well! how did Arkwright do it?" said Harry, eagerly.

"By passing the cotton between rollers," said his father. "By passing it successively between three pair of rollers, placed near each other; the upper roller of each pair is pressed down with different weights. The first pair of rollers, through which the cotton is pressed and passed, turns slowly, the second faster, and the third more quickly, each with a steady motion. Now suppose, Harry, that the last pair of rollers moved eight times as fast as the first pair, then, eight times more length of cotton would pass between that pair of rollers than what had passed between the first pair, consequently the same quantity would be drawn out to eight times the length and eight times the fineness."

"Very ingenious," said Harry. "I wonder how Arkwright came to think of passing the cotton between rollers."

"It is said, Harry," replied his father, "that



Arkwright had had frequent opportunities of seeing, in iron works, iron bars drawn out, by being passed between rollers, and he afterwards applied this idea to the drawing out of cotton."

"I am surprised he ever thought of it," said Harry; "because the fine fibres of cotton wool, and iron bars, are so different."

"Still there is some likeness," said Lucy, "in the motion of drawing out the thread thinner and thinner, and smoother and smoother. So you see, Harry, there is good sometimes in observing likenesses."

"What I have said," continued their father, "may give you some idea of the effect of the action of the rollers; I should further tell you, that in the undermost of each pair of rollers were cut fine little grooves, or furrows, along the whole of its surface, to roughen it so as to prevent the cotton from slipping. The upper rollers were covered with leather. The passing the cotton *rovings* between these rollers, pressed together as I have described to you, with different weights, and moving with different velocities, had the same effect upon the cotton as that which is produced by the pressure and motion of the spinner's finger and thumb, smoothing down the loose fibres, laying and keeping them parallel with each other, and at the same time drawing them out so as to make a finer thread."

“ So at last,” said Lucy, “ Arkwright did by the use of rollers what a woman did at first by the motion of her finger and thumb.”

“ Yes,” said Harry ; “ but consider how much more was done in the same time, in one day, perhaps, by the rollers, than a woman could do in her whole life spinning. And how difficult, and how very ingenious it was, to imitate by machinery that motion of the finger and thumb. And this was Mr. Arkwright’s great invention ?”

“ It was,” said his father.

“ But what became of the spinning jennies,” said Harry ; “ were they laid aside when Arkwright made these improvements, and erected these mills ?”

“ The spinning jennies are very much laid aside, I believe,” said his father, “ in consequence of the defects which I mentioned. But for some purposes the cotton they spin is preferable, and for these the jennies are still used.”

“ Since Arkwright’s time, have any great improvements been made, father,” said Harry.

“ No improvement has been made in the *principle* of his mode of spinning, but many in the simplicity and the perfecting of the machinery. The use of steam and steam-engines, instead of water and water-wheels, for keeping these mills in motion, is in many places of great importance. Of the various improvements in the detail of the

machinery, I will only mention one to you, an invention made by a Mr. Samuel Crompton."

"That's right," said Harry. "I am glad papa always remembers and tells the name of the inventors."

"Mr. Crompton observed and joined together much that was essentially useful in Hargreave's spinning jenny, and in Arkwright's rollers, or *twist frame*; and he made a third machine, which combined many of the advantages of the former two, and which is preferred for spinning fine cotton, but is inferior in spinning coarse. This machine is called the *mule*."

"I should like to see the mule," said Harry.

"But you cannot see and understand every thing at once," said his father.

"I hear the workmen coming from dinner," said Lucy.

"Now we shall see this cotton-mill of Arkwright's at work," said Harry.

The guide coming in at this moment, and hearing the last words Harry said, and the name of Arkwright, began to speak of the immense fortune which Sir Richard had made by his inventions and improvements.

"Sir Richard!" interrupted Harry, "how did he grow into Sir Richard?"

"The king conferred upon him the honour of knighthood," answered the workman, and he

went on speaking of the fine houses and estates Sir Richard Arkwright and his descendants have purchased.

“ Did you ever hear, sir,” said he, “ of the birth-day present which Sir Richard’s son made to each of his six sons. Each found on his table, on the morning of his birth-day, twenty thousand pounds.”

“ Twenty thousand pounds ! Six times twenty,” said Lucy : “ that is one hundred and twenty thousand pounds ! What a sum ! ”

“ And all the consequence of one man’s invention,” said Harry.

“ And industry and perseverance,” said his father. “ Arkwright had great difficulties to struggle with, not only in perfecting his contrivance, but in reducing it to practice, and in establishing his right to the invention.”

The workmen were by this time pouring into the room, men, women, and children, and the machinery was set a-going again in a minute or two, and all were busy. Even Lucy, as well as Harry, had some idea of what was doing. They knew the use of the spindles and of the cylinders. Without being perplexed by the smaller parts of the machinery, they had a complete view of each process that the cotton-wool undergoes, after it is taken out of its pod, till it is manufactured into the finest cotton.

As they were leaving one of the rooms, the guide showed them a heap of hanks or skeins of cotton yarn, all which, as he told them, had been spun by the mule from a single pound of fine cotton.

“There are here three hundred and fifty hanks,” said he, “and each hank would measure eight hundred and forty yards; and the whole, if stretched out, would make a thread one hundred and sixty-seven miles in length.”

“One hundred and sixty-seven miles!” repeated Lucy, “what would your flying spiders say to this, Harry?”

“Or your silk-worms, Lucy?” said Harry; “I think your good active best of silk-worms never spun more than a silk the length of six miles.”

“At any rate,” said Lucy, “men and women beat spiders and silk-worms both in spinning.”

Her father observed, that the proper object of comparison between rival spinners is, not the length of the thread, but the fineness. “And I apprehend,” said he, “that either a silk-worm or spider’s thread is as fine as one fibre of cotton wool; and the finest thread of cotton *must* be composed of many fibres.” So that, notwithstanding Lucy’s exultation in the superiority of men and women spinners over worms and spiders, Harry was compelled to give judgment in favour of the animals.

“ But their superiority is owing only to instinct, and ours to ingenuity and reason, you know, Harry,” said Lucy. “ It is no merit of theirs, that they have their materials prepared for them better than we have.”

Here the debate about the spiders and silkworms was interrupted by the entrance of a gentleman, who was the principal proprietor of the cotton manufactory, and the conversation turned upon the prodigious sale of cotton goods and muslins in different parts of the world, especially in England.

“ You know, madam,” said he, turning to Lucy’s mother, “ that muslins were formerly all made in India ; and that it is only thirty or forty years since we first attempted to make them in England, and not till within these few years that we have brought them to their present perfection.”

Lucy’s mother was well aware of this ; she said she remembered, when she was a child, seeing some of the first muslin made in England, and that it was coarse and rough, and looked ill, and wore ill ; and that no one then thought English could ever equal Indian muslins. But now it is difficult for the nicest eye to detect the difference in the appearance and in the wearing ; they are as good, if not better.

Harry’s father turned to him, and whispered, “ If you put me in mind, I will tell you some

other time by what ingenious and bold contrivance that roughness in the first English muslin, of which your mother complained, was afterwards prevented."

The gentleman continued speaking, and when Harry heard his voice again he was telling of the immense quantity and value of the muslins now made in England and Scotland.

"All this we owe," said he, "to our using ingenious machinery in these countries, instead of doing every thing by the labour of men's hands, as in India. Perhaps you are not yet aware, sir," said he to Harry's father, "of the magnitude of the cotton manufacture. Its machinery earns for England one thousand pounds every working hour. Forty thousand pounds weight of cotton wool is spun, and in three minutes the length of the thread spun would more than circumscribe the whole earth."

As this was said, they were passing through an apartment, where Lucy saw a machine for winding the pretty little balls of cotton—she wished to stay to look at it.

"Oh! papa, may I not look at this?"

"But her father answered, "No, my dear, you have seen and heard enough—quite enough; if you were to see more you would confuse what I hope is now clear in your heads. Come away"

GAS-LIGHTS.

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IN the evening Lucy acknowledged that she was rather tired, and was glad to rest, and to stay with her mother, who did not wish to go out again. But Harry, boasting that he was as fresh as ever, was proud to be allowed to accompany his father, who was going to walk out to see the town. After passing through several streets, they came to a broad public walk, on a high terrace, shaded with trees, from whence, looking back, they had a fine view of the town by the red light of the setting sun, which beautifully illuminated several windows, especially those of a Gothic church. As Harry was returning through the streets, he regretted that Lucy had not been with them, and he asked his father whether they were to go away from this town early in the morning, or if he would stay another day; his father, who, perhaps, was thinking of something else, answered, in an absent manner, "I do not know, my dear; that will depend upon circumstances."

Harry was considering, as he trudged on, what could be meant by "that will depend upon circumstances," when, on turning the corner of



the street, his thoughts were stopped, and his eyes struck, with a sudden blaze of lights. Harry's admiration lasted in silence the whole length of the street; when turning into another, still more bright, he exclaimed,

“It is almost as light as day! Father, what kind of lights are these, and of what are they made?”

His father told him that they were called gas-lights, and that they were made of gas obtained from coal.

Harry asked, “How is gas different from other flame of candle or fire?”

His father told him, that *all* flame is gas set on fire. “In a common fire, in a candle, or lamp, what you see, and call flame, is gas, which, when set on fire, continues to flame when exposed to the air.”

Harry asked, “How is gas *got out* of coal?”

His father told him, “By the coal being strongly heated in iron vessels called retorts, which have but one opening for the gas to escape from into the reservoir where it is preserved.”

Harry next inquired how the gas gets from the reservoir to the small pipes, so as to light all the houses in the street, where he saw gas flaming at the windows.

“Suppose a tumbler to be inverted in a basin of water,” said his father, “you know, that as there

is air withinside of the tumbler, that air will prevent it from sinking in the water."

"Certainly," said Harry.

"But you may put weight upon the tumbler, till you compress the air in the inside, and then the water will first rise to supply the place of the compressed air. And what will happen afterwards, Harry?"

"I think nothing would happen, father, but that the water in the basin would continue pressing up the air till it had forced it into the smallest space possible."

"Very true, to the smallest space to which it is possible for the water to compress it; but the air being compressed, its elasticity continually increases, till it resists the pressure of the water. Now suppose one end of a small pipe were introduced under the edge of the tumbler, what would happen?"

"The compressed air would be forced into the pipe to be sure," said Harry.

"And if the pipe were open at the other end?" said his father.

"The air would go out at the other end," said Harry.

"And what would happen to the tumbler?" said his father.

"The tumbler would continue descending till all the air was driven through the pipe," answered Harry.

“ It would so. Now, instead of common air, suppose your tumbler filled with gas, exactly the same thing would take place. This is called a gas holder, and this is the manner in which the gas is continually forced from the reservoir through the pipes.”

“ I understand it,” said Harry; “ and I hope you will some time or other show this experiment to Lucy. It would be very easily done with a glass and basin.”

“ You may show it to her yourself,” said his father.

“ Does the gas light immediately of itself, when it comes into the air?”

“ No; when a person wants to light it he holds a candle to it, and it flames as you see in the open air.”

“ Suppose it was to rain, or suppose the wind blew strong,” said Harry, “ what would become of these lights? Look at these flaring, without any glass round them, in the open window, in this butcher’s shop? Would not they be extinguished?”

“ Not by slight rain or wind,” said his father. “ One great advantage of gas-lights is, that they are not easily extinguished by rain or wind.”

Harry’s admiration increasing, the more he heard of their advantages, and considered their convenience, and beautiful brightness, he wondered why people had not thought of using them sooner.

And he asked if this gas had never been known to exist till now.

His father told him, that it had been long known as what we see in the flame of fire and candles ; but that till lately no one had thought of obtaining it in quantities, and bringing it into common use, in the manner in which he now saw it. " I could tell you, Harry, two curious anecdotes, which I heard from a friend."

" Can you, father?" said Harry. " Then pray do. Will you be so good as to tell them to me now?"

" If you will mind where you are going, and not run into the gutter," said his father.

" About forty years ago, a certain Lord Dundonald had a patent for making what is called *coke* from coal. Coke is half-burnt coal, such as you have seen used in forges ; to obtain the coke he half-burned the coal, and the tar and gas which were in the coal were, by this process, separated. The coke being his only object, the gas was conducted under water many hundred yards, in large tunnels, in order to condense the tar, and the gas escaped out of a high chimney. How it became lighted my friend said he did not know ; but once lighted, it continued to burn, and the flame illuminated the country for twenty miles round."

" I wish I had seen it," said Harry. " How

grand and beautiful it must have looked! But when people saw this, I wonder no one thought directly of making use of the gas, and of obtaining it in the same way for lamps."

"It is the more surprising," said his father, "because it was, in fact, a gas apparatus, like that at present used, only the gas was suffered to escape and waste itself."

"But, father," said Harry, "what was the other anecdote?"

"Long before this Lord Dundonald's time, there was a chemist, whose name I do not recollect, who made gas from coal, and stored it in bladders, and frequently amused his friends by pricking a hole in the bladder, and then applying a light to it. This was *portable* gas, such as people are now beginning to use, only in a different case."

"Well, this is more extraordinary still," said Harry; "because that gas in the bladder was in such a convenient form for carrying about; it is wonderful that neither he, nor any of his friends who saw it, ever thought of making use of it for lamps. I wish I had been by when he showed the bladder, and pricked it, and set fire to the gas. Father, even such a boy as I might have thought of it, might not I?"

"You might, Harry," said his father; "but how few men, to say nothing of boys, observe

what they see any day, or every day, or think of what use can be made of it!"

"But so striking a thing! and so obvious a use!" said Harry. "What seems so easy and natural, now that it is done!"

"True, Harry. The thing was there before their eyes, but useless, because they did not think of making use of it."

"And for forty years and more!" said Harry.

After a long silence, during which Harry stumbled sundry times, he exclaimed,

"Father! I am thinking—"

"Not of where you are going," said his father.

"But I am thinking, father, that there are a great many other little things, which people have not yet observed, that may lead to great things, if people think of putting them to use."

"Undoubtedly," said his father: "in this you are very right."

"And, father, do you think that, if I try to observe and consider what use I could put things to, I shall ever discover or invent anything new?"

Harry was here interrupted by stumbling over a walking stick, with which a man whom they met was feeling his way, and which Harry had not observed.

"I wish that man would not poke out his stick so," said Harry; "it nearly threw me down."

"The man begged his pardon—said he was

blind, and was forced to grope his way with his stick. Harry now begged his pardon for running against his stick, and guided him across to the next street, and the old man wished him a good night, and said,

“May you never be blind as I am. And whenever you are old, may you meet with help as I have from you.”——

As soon as the blind man had left them, Harry began to recollect what he was saying when he first met him, and he would have resumed the conversation, but his father told him, that he could not talk to him any more now, and that he must walk fast, for it was getting late. Harry trudged on as quickly as he could. His father thought he must be tired, and so he was, but he scorned to complain.

It was late when they reached the inn. Tea had been waiting some time, and Lucy, after struggling to keep herself awake, had fairly given up the point, and had fallen asleep, her head resting on her arms, which were crossed on the table. She was so fast asleep that she could hardly be wakened sufficiently when Harry came in, to ask whether he had had a pleasant walk. After swallowing a cup of tea, with her eyes half shut, she submissively obeyed the signal of the chambermaid with bed-chamber candles, and retired to that rest which she much wanted.

Harry would stay up to listen to a conversation between his father and a postilion, from which he hoped to discover what would be done in the morning, and what was meant by "that will depend upon circumstances." But before he had made this out he fell fast asleep across the great black trunk, where he lay unobserved, till the waiter tumbled over his legs, and let fall a spoon upon his head. Harry started up. He had dreamt, as he said, that he had been struck by the beam of a steam-engine. His mother exhorted him to go and dream in bed. She took up a candle to light him on his way; but he turned, and stood looking at the postilion, astonished to see him still standing there, and his father still talking to him.

"Mother! what an immense time this man has been standing talking!" said Harry.

"Not above five minutes, my dear," replied his mother.

"Five minutes only!" cried Harry. "I have been in that time all the way to Germany, and back again, at a palace magnificently lighted up with flaming crocuses of gas. I asked whose house it was. 'Do not you know!' said the man. 'It is your friend the great Otto Guericke's.' I was not surprised that he was living still. I only said I would go and see him. But the inside of the palace was like a cotton-mill, and there was



a great steam-engine going on working away. Through all the workmen, and women, and children, I went on, asking for Otto Guerick, till at last one guide-man said he would show me the way to Otto's laboratory, where he was trying experiments *always*, in his silk night gown. But the man said the laboratory was at the top of the house, and asked if I could follow him up high ladders. Oh, yes! I said, as high as ever he pleased. So I went scrambling on after him, and, if my foot had slipped, I should have gone down, down, down, I do not know where; but I reached the top, and a door opened, and I heard the rustling of Otto Guerick's silk night gown, and I was just going in when that spoon, which I thought was the beam of a steam-engine, fell upon my head. Oh, mother! I wish it had not fallen. It was so provoking to be wakened at that moment, just when I was going in to see Otto Guerick. I wish that I could dream it over again."

"You had best sleep again, Harry, my dear," said his mother, "and this time sleep in your bed. Come," said she, showing him the way through the passage to his bed-room, where she put into his hands his night-cap, which Lucy, even in the depth of her own sleepiness, had remembered to leave ready for him.

Harry slept nine hours without intermission, but he saw no more of Otto Guerick, or his gas

illuminated mansion. He was still fast asleep when his mother called him. During breakfast his father and mother talked about the various noises they had heard in this inn all night, and by which they had been so much disturbed that they could not sleep. His mother said, that a coach had arrived or set out every half hour, that she had heard bells and calls, hostlers and chambermaids, and waiters running to and fro in the passages continually, and people calling perpetually for their trunks, and portmanteaus, and parcels, and bills. Harry's father said, that the partition between their room and the next was so thin, that they could hear every sound ; and there was a man in that room, who seemed to be pulling off his boots, and throwing them down, and throwing wooden legs after them all night.

Harry and Lucy looked at each other when their father and mother talked of all these noises ; they were surprised, for they had slept so soundly that they had not heard them.

MATLOCK.

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DURING breakfast Harry told Lucy that it depended upon circumstances whether they were to go on with their journey to-day, or to stay in this town. Lucy said she was not at all the wiser, as she did not know what circumstances he meant. Their mother told them, that it depended upon a letter which his father expected to receive by the post, to tell him whether his friend would return home this day or not. Harry's only reason for wishing to stay was, that Lucy might see the pretty walk he had taken the preceding evening; but as it was now raining, they could not walk, and he was glad that they were not to spend the day at the inn, where they had nothing to do.

"What shall we see next?" said Lucy, as she got into the carriage. "I like going on to something new."

"If you had your choice, Harry, what would you wish to see next?" said Lucy.

"A mountain," said Harry, who was faithful to his old wish for a mountain to measure with his portable barometer. While he had been taken up with the cotton manufactory, and the steam-

engine, and the gas-lights, this wish had slept in his mind; but it was now awakened with fresh eagerness. As they journeyed on he eyed the outline of every hill on the horizon. But he observed a discreet silence upon the subject. Even when Lucy exclaimed, "Here's a mountain coming for you, Harry!" he replied soberly, "So I see, my dear, but it is not near enough yet; I will speak when I think it is time."

At last, when they came into Derbyshire, and into the hilly parts of that county, Harry spoke, for he thought it was time.

"Father! here are plenty of mountains! will you be so good as to stop the carriage, and to let me get out, that I may measure this one which is almost close to us. I will not detain you above twenty minutes, mother, if you could be so good as to wait—in ten minutes I would run up, in ten minutes I would be down again! May I, father?"

"No, Harry," said his father, "we cannot stop for you now. It would detain us much longer than you imagine. Your eye deceives you, in judging of distances and of heights to which it is unaccustomed."

"For your comfort, Harry," added his mother, "we are going to Matlock, a place where you will find yourself surrounded by fine mountains, upon which you may try your own and your barometer's

measuring powers at leisure, for we shall stay there two or three days."

"Delightful!" thought Harry. "Thank you, mother," said he.

Presently they entered a narrow but beautiful valley; a stream ran through it, and there were hills on each side, whose banks were covered to a great height with trees of the softest foliage, and of various shades of green. Above, high above the young feathery plantations, and the scrubby brushwood, rose bare, whitish rocks. Sometimes stretching in perpendicular smooth masses, sometimes broken in abrupt craggy summits, huge fragments from which had fallen into the river below. The river flowed tranquil and placid till, when opposed by these massy fragments, it foamed and frothed against their immoveable sides; then, separating, the waters whirled round them in different currents, and joining again, the stream ran on its course, sparkling in the sunshine. The road now lying beside this river, brought them soon to the pretty straggling village of Matlock.

The morning after their arrival they went out to walk. At a little distance from the hotel where they lodged was a walk up Masson-hill. It was a zigzag path, cut through a wood of fir-trees, reaching to the summit, called the Heights of Abraham. They went part of the way up this path, and Harry was eager to go to the very top, but

his mother was not able, she said, to go quite to the Heights of Abraham; she, and his father, and Lucy, went to see a cave in this hill; but his father told Harry that he might go on by himself, if he liked it, to the top of Masson-hill, and take its height with his barometer, and compare this with the reputed height, which is said to be about 750 feet.

Harry, to Lucy's surprise, stood hesitating, with his barometer in his hand, instead of going on with the alacrity she expected.

"What is the matter? would you rather come with us to see the cave?" said Lucy.

"No," said Harry. "that is not the thing."

"What then?" said Lucy. "Do you want me to go with you? I should like it: but you know mamma said, that I must not go running about everywhere with you here, as I do at home; I must stay with mamma. But you look afraid to go by yourself," added Lucy, laughing.

"Afraid! my dear, I am not the least afraid to go by myself anywhere in the world," said Harry, proudly: "I am not going to do anything wrong: what should I be afraid of?"

"I do not know," said Lucy, "that is what I want you to tell me. I am sure there is something you do not like, or else why do not you set off?"

"There is something I do not like," said Harry,

“*that* I acknowledge. I do not like to meet those people who are there, further up on the walk.”

“What harm will they do you, Harry?” said his father.

“No harm, father; only I do not like to meet them, because they are strangers.”

“But since, as you observed, Harry, you are not going to do anything wrong, you need not be ashamed—I will not say *afraid*, to meet them!” said his mother.

“That is very true, mother,” said Harry, “I know it is very foolish; well, I will conquer it; I will go on by myself,” added he, resolutely.

“Go on and prosper then,” said his father. “I dare say that those people will never think about you, unless you do something to attract their attention.”

Harry walked off as fast as he could; nor stopped till he reached the Heights of Abraham. Then he took out his barometer, and noted down the height at which the mercury stood, both in the barometer and thermometer. Then he went down the hill, and, as soon as he had reached the bottom, he looked at the mercury again in each, noting down carefully these heights also. Finding a retired nook, away from the public path, he sat down to work at his calculations, resolved not to stir till he had completed them. On his baro-

meter there was engraved a table of the heights at which the mercury stands at different elevations, calculated when the atmosphere is at the freezing point. Besides this, he had taken care to bring with him a certain little book\* containing "An expeditious method of calculating altitudes;" the want of which had, in his first attempt to measure the church, prevented his succeeding to his satisfaction. Now understanding and following the directions contained in this little trusty companion to his dear portable barometer, he made his calculations sufficiently accurate to satisfy his conscience. He brought his answer within two feet of the height, which his father had told him had been determined by previous measurement.

He next went to look for the cave.

It was a large, deep, dark cavern, at the further end of which he perceived light; and as he advanced he saw the forms of men—of the guides, who held torches, and he heard Lucy's voice, and the voices of his father and mother, and soon distinguished their figures. They were all looking up at the roof, on which the guides, with raised

\* "An Expeditious Method of determining Altitudes with the new Portable Mountain Barometer; with a description of that instrument, by Sir Harry Englefield, Bart."

A little tract, which is, or ought to be, sold with every portable barometer.



torches, threw a strong light. From the roof, which appeared encrusted all over with yellow earth, hung multitudes of what seemed like earthy icicles, of the same colour, and of enormous bulk.

“ My dear Harry! are you there?” cried Lucy, “ I am glad you are come; I was so afraid you would not come in time to see these! Are not they beautiful? Do you know what they are? They are stalactites.”

“ And how came they there?” said Harry, “ and what are they? You tell me they are *stalactites*, but that tells me nothing but their name.”

“ It is a good thing in the first place,” said Lucy, “ to know the name, because then we can ask people questions, and then they will know what we are talking about.” She told him all she had just learned, from what she had heard the guides and her father say; that these stalactites were formed by the water oozing through the roof of the cavern, and depositing, as it trickled down, some calcareous earth, which it had dissolved in its course through the soil and rocks, along and down which it had passed. She believed that these rocks were calcareous, or limestone. She had further heard one of the guides say, that some stalactites found in this country became almost as hard as stones, were of various colours, and had been polished and made into necklaces, and

different ornaments. The guides had broken off from the sides of the cave some of the stalactites, and had given pieces of them to Lucy; some of these, which had been newly formed, were softish, and crumbled easily when pressed between the fingers; some were a little harder and crisp, cracking rather than mouldering when pressed; others were as hard, Harry observed, as some petrifications which he had seen in his uncle's collection. His father told him, that those petrifications had been formed in the same manner in which these stalactites were formed; and the guides said that they would show him plenty of petrifications, and crystals, and beautiful spars of different colours, for which Derbyshire is famous.

While all this was saying, Lucy's mother, who did not like standing still long in this damp cavern, had by gentle degrees, alternately drawing Lucy on by the hand, and urging Harry forward by the shoulder, kept moving onwards, till they found themselves again at the entrance or the exit of the cave; they were glad to see the day-light, to feel the fresh warm air, and to tread again on dry ground.

Several boys and girls met them in their way to the hotel, with baskets of crystals, spars, and petrifications. In one basket Lucy saw a petrified wig. The guides told her, that the people of Matlock amuse themselves by putting wigs and

different things in these calcareous springs, to have them, as they say, *converted* into stone. Such they seem to turn into, as no appearance of the original substance is left except the form. But, as Harry observed, it is not that the substance turns into stone, but that the calcareous deposition covers it all over, and the original substance in time decaying, nothing afterwards is left but calcareous stone. In another basket Lucy saw spars of various colours; some of purple and some of amber colour, of different shades, in rainbow stripes, or cloud-like streaks. Some of these spars were made into hearts, and necklaces, and boxes, and urns, and eggs, and various trinkets.

Lucy's mother told her that she might choose any one of these things she liked.

Lucy chose a polished egg, of shaded purple spar; it seemed transparent, and looked as if you could see into it to a great depth, but when Lucy tried to open it, she found that it did not open.

“Of what use then can it be?”

It had a little gold ring at the top of it, and was intended to be used as a netting weight. Lucy had been long making a purse for her father: she was sure that the pleasure of using this pretty weight would encourage her to go on netting it, as soon as ever they should come to the end of their journey. But how was the egg

to be carried? Her father said he could not have it rolling about the carriage; and the pockets were already fully occupied. Lucy would have been reduced to take a flat heart, instead of her beautiful egg, if Harry—"good at need"—had not stepped forward, and opening, wide as he could stretch, the mouth of his waistcoat pocket, bid her put her egg in there, "where there is plenty and plenty of room," added he, shrinking in his stomach to show the ample space.

"My dear Harry, you are very good," said Lucy.

"Not the least," said Harry; "I should be very bad, if I did not recollect how good you were about my camera obscura, which you crammed into the trunk. Come, drop your egg in here at once, and say no more about it."

She dropped it into the pocket.

"But, my dear Harry, it looks as if you had a great swelling; people will stare."

"I do not care," said Harry; "let them stare."

This was indeed, as Lucy knew, a great proof of Harry's affection; for in general he disliked excessively to be stared at, and avoided every thing that could bring upon him such a misfortune.

"Besides," added he, patting down the egg in his pocket, "it does not stick out *now* more than my ball, which I have often carried here, and nobody ever noticed it, except my mother. Indeed, now I have got it into the corner, you see

it is not a greater lump than my pocket handkerchief, which sticks out as much on the other side, so all's right."

"But if you were to tumble down, the hard egg might hurt you, Harry."

"I might hurt it," said Harry, "for I should break it, I suppose. But, my dear, I never, that is hardly ever, tumble down; and now I have this egg, it will make me more careful; so say no more about it. Now I want to tell you about the Heights of Abraham."

He had prudently forborne to speak of his operations, while her head had been full of stalactites, and spars, and wigs. She now listened to him with due sympathy, and was delighted when he informed her, that his barometer measurement came right within two feet. His father congratulated him upon his success, with which he was particularly pleased, because it was the consequence of perseverance. He was glad to see that his son would not be satisfied till he had rectified his errors, and had been as exact as he possibly could. This promised well for his future progress. All the rest was mere child's play. "Very few uncles," said he, "would have given a portable barometer to a boy of your age. I am glad you can prove to him that you have been able to use his present, and that it has been of service to you, Harry."

“ It was lucky for me,” said Harry, “ that there was nobody by, on those Heights of Abraham, when I was at my work ; and lucky too, when I came to the bottom of the hill, that I found a snug place, out of the way of every body, where I made my calculations, or else I am sure they would have been all wrong.”

“ That would have been a pity !” said Lucy, “ after all your pains.”

“ Therefore it would be a great advantage to you, Harry,” said his father, “ if you could learn to calculate, and to be able to go on with whatever you are doing, when people are looking at you, as well as when you are by yourself ; because you cannot hope always to be alone when you want to think, nor can you always hope to find snug solitary places for your calculations. Every common schoolboy is forced to learn his lesson, and to cast up sums without being disturbed by strangers. All this is easily learned by practice.”

“ Aye, by practice, I dare say,” said Harry.

“ And I will tell you what you can do by your own sense,” added his father : “ upon every opportunity try to conquer your dislike to going among strangers, and then you will get over your bashfulness.”

“ Father, then, if you please, I will go with you to-day, and dine at the public table, instead of staying with my mother and Lucy.”

“ Right, my boy, so you shall.”

When dinner time came, Harry went along with his father, and, as he walked into the public room, said to himself, “ I am doing nothing wrong : I need not be ashamed : I will not be bashful.” Still a mist of confusion came before his eyes, when, seated beside his father, at a very long table, he saw opposite to him a line of strangers, and on all sides of him strangers ! He scarcely ventured to look up at their faces. He was seized with one of his fits of the cramp of bashfulness, under which he sat suffering and stiffened, blushing, and conscious that he was blushing, scarcely able to answer “ Yes,” or, “ No thank you,” when he was asked what he would have. He thought that every body must take him for a fool, and this made him feel more uneasy and awkward. He scarcely saw, or knew what he was doing : he threw down first one thing, then another ; first his fork, then his bread in reaching for the fork, then the salt cellar, and at last a glass of water into his father’s plate. It was well it was no worse. His father set the glass up again, sent away his plate, and said nothing about it. Harry wished he was in his mother’s room, or under the table, or anywhere but where he was. His blunders and disasters had more and more provoked him with himself, and he thought he had disgraced himself for ever,

and that people must think he was a vulgar creature, or a child not fit to dine with men or gentlemen, nor used to dine anywhere but in the nursery. His face was by this time all burning with shame, and scarlet up to the roots of his hair.

While he was in this condition, the lady who was sitting opposite to him, asked him if she should help him to some oysters : he happened not to like oysters, and he answered, " No, thank you," in rather a surly tone ; and then, thinking he had done wrong to answer so gruffly, held his plate out, and said, " If you please, ma'am."

" But you have not finished your sweetmeat ; I did not observe that," said the lady. " You do not like sweetmeats and oysters together, do you, my dear ?"

" I do not care, ma'am, thank you," said Harry.

" Are you the young gentleman whom I met this morning with a barometer in his hand ?" said the lady.

" I do not remember meeting you, ma'am," said Harry ; " but I had a barometer in my hand."

" Really : I hardly thought you were the same. May I ask what you were doing with that barometer ?"

" I cannot explain it to you, ma'am, now," said Harry.

A gentleman luckily asked her at this moment



to drink a glass of wine, and she turned away from Harry, and thought no more about him or her question. Still his father took no notice of him, but left him to recover himself by degrees, and to find out the truth, that people were thinking of themselves much more than of him. Gradually he came to the use of his senses and understanding, so far as to hear and comprehend something entertaining, which a gentleman was relating. As soon as Harry became interested in listening to what this gentleman was saying, he unstiffened, looked up, moved forward on his chair, forgot his blushes and his blunders, and all his fears of having disgraced himself; in short, he forgot *himself* altogether.

The gentleman was giving an account of the plundering of a vessel, which had been stranded on the coast of South Wales, in St. Bride's bay. It was a transport laden with ordnance stores from America.

Harry made out, that "ordnance stores" here meant gunpowder and guns. Some of the people on the coast saw the signals of distress, which were made by the persons on board the vessel; but instead of putting out boats, and going to their assistance, these wicked people thought only of plundering the vessel, and carrying away every thing they could for themselves. They assembled on the beach, and waited there till the ship was

driven on shore, and wrecked. While the poor people on board were trying to save their lives, these plunderers were busy carrying off all they could from the wreck. They boarded her as soon as possible, because they knew, that as soon as ever the gentlemen of the country should hear that a vessel had been wrecked, they would come to assist the sufferers, and to prevent the plunder. The mob made such haste, that they got possession of their prey, and landed a considerable quantity of gunpowder from the stranded vessel. Many of the plunderers were loaded with as much as they could carry, while others were struggling for their share of the booty, as their confederates were dragging it on the shore.

In this scene of confusion, and in these struggles, a quantity of the gunpowder was scattered on the shore, and on the rocks. One of the ringleaders of the mob quarrelling with another, who had got possession of a musket, which he wanted to have for himself, seized it and threw it from him with violence. What happened none could exactly see, as it all passed so quickly; but, probably, the musket had struck against a flint—a single spark was enough to set fire to the gunpowder which was scattered over the rock. One explosion after another was heard, one train communicated to another, and in a few seconds the whole strand and rocks seemed wrapped in fire and smoke.

Many of the plunderers were killed on the spot ; others were dreadfully maimed, and died lingering deaths. The man who threw the musket absconded, and was never heard of afterwards.

While Harry listened to this dreadful story, pity for the shipwrecked people who perished for want of timely assistance, indignation against the wretches who thought only of plundering the wreck, wretches such as he could hardly believe to exist, horror at the catastrophe, an awful sense of the justice of the punishment which they immediately brought upon themselves, and satisfaction that they gained nothing by their crime—altogether filled his mind ; and these successive sentiments and reflections so absorbed him, that he completely forgot every thing else, forgot where he was, and who was by, and all his own little foolish feelings. What was become of his bashfulness ? It was all gone ; gone off with that superfluous anxiety, which he had felt about the opinions the surrounding people might form of him.

JOURNEY.

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AFTER they left Matlock, the road appeared uninteresting to our travellers. But they had books in the carriage, and Lucy's mother began to read at first to herself, and afterwards to her companions, when she found any thing that she thought would entertain them.

“ Here is an account,” said she, “ of the various stinging insects which infest parts of South America; where the inhabitants pass their lives complaining of the insufferable torment of the moschettoes.”

“ Will you be so good as to read it to us now?” said Lucy; “ I am so very comfortable, with your dressing box under my feet.”

“ Persons who have not navigated the great rivers of South America, for instance the Oronoko and the Rio Magdalena, can scarcely conceive how, at every instant of life, you may be tormented by insects flying in the air, and how the multitude of these little animals may render vast regions almost uninhabitable. They cover your face and hands, pierce clothes with their long sucker, in the form of a needle, get into your mouth and

nostrils, and set you coughing and sneezing whenever you attempt to speak in the open air. In the villages, on the banks of the Oroonoko, which are surrounded by immense forests, the plague of flies affords an inexhaustible subject of conversation. When two persons meet in the morning, the first questions they address to each other are, 'How did you find the *zancudoes* during the night? How are we to-day as to *moschettoes*?' \*

"At New Barcelona, the wretched inhabitants generally stretch themselves on the ground, and pass the night buried in sand, three or four inches deep, leaving out their heads only, which they cover with handkerchiefs. Further on, the traveller fares worse, for he comes to the region of the *sorrowful people*, as they are called, who are doomed to be for ever tortured by these insects. One poor monk, who had spent, as he said, his twenty years of *moschettoes*, in that country, desired Humboldt and his companions to tell the people in Europe what the poor monks suffer in the forests of South America. When an inferior monk commits any fault, his superior exiles him to this country, and they call it being condemned to the *moschettoes*."

Lucy asked her mother if there was any more that was entertaining about the *moschettoes*. Her mother read to her an account of the different

\* Humboldt, Personal Narrative, vol v.

kinds of stinging insects, which *mount guard* at different hours of the day and night. Just at the time, when one party are flying away, and when the next have not fixed, or, as soldiers would say, at the time of *relieving guard*, there is an interval of repose. The different hours of the day and night are marked and known to the inhabitants by the different stinging flies, so that, as they say, they could tell blindfold what hour it is, by the sting of the last, or the hum of the coming torment.

“Horrible creatures!” said Lucy, “I am very glad we have none of them in our country.”

“Horrible!” repeated Harry, in an absent tone: he seemed to be heartily glad to have this history of the moschettoes finished, and to get rid of them. They had prevented him from fixing his attention upon something which he wanted to think of.

The moment his mother’s closing tone announced that she had finished, he threw himself half over his side of the carriage, and began to watch the hind wheel.

“Is there any thing the matter with the wheel, brother?” said Lucy.

“Nothing, my dear, I am only thinking of something.”

“Take care, Harry,” said his mother, “I think you will fall out.”

“No, thank you, mamma, there is no danger

of that, I am holding by the holders," said Harry

There was nothing more to be said about the safety of the position he had chosen; something might, perhaps, have been said about its unsociability, but his mother went on reading, and his father and Lucy were listening to her.

"Oh! Harry!" cried Lucy, "listen to this, here are the termites, the great ants, will not you hear about them."

"Thank you," said Harry, "I have heard enough about them.

She left him to his wheel for some time, but presently returned again with—

"Oh! Harry, did you hear about the jaguar that came bounding to the shore to play with the little girl, and tore the skin of her forehead, and she drove him away with the bough of a tree? only think!—the jaguar!"

"My dear Lucy, you jogged me and put me out in my count. Now I must begin all over again," said Harry.

She drew back, but after some little time exclaimed again—

"Harry! Oh! Harry, hear this! a *shirt tree*! My dear Harry, a real name of a real tree, fifty feet high, shirts ready made grow upon them without a seam!"

"One hundred and fifty-five! I am very glad

of it. One hundred and fifty-seven," said Harry, continuing to count on.

"If the shirt tree won't do, nothing will," thought Lucy; and she sat down and sat still during many pages; then starting up again, she threw her arm round him.

"Oh! Harry, Harry; the most beautiful story you ever heard. A mother in search of her children, who went through such difficulties, and such places, as no person had ever the courage to go through before! and lived for four days on nothing but black ants, and was stretched upon the rack at last, and tortured. Oh! Harry, won't you listen to the end of it?"

"Two hundred and twenty-one: my dear, another time you will tell it to me; two hundred and twenty-two."

Lucy gave it up, left him to himself, and listened to the end of the story; sorry, however, that he could not, or would not enjoy the pleasure with her.

After this story of the Piedra della Madre, or rock of the mother, was finished, Lucy's mother was tired reading aloud: her father took up a book to read to himself; and Lucy, who had the happy power, either travelling or at home, of being able to amuse herself, began to point out to her mother every thing or animal she saw on the road, which she thought would look pretty in drawing.



“ Look, mamma, at that woman who is crossing the field with a basket of hay on her back, and the cow following, without her perceiving it, and eating the hay, is it not like one of the vignettes in Bewick? Mamma, as you are not busy now, whenever I see what I think would be a good Bewick on the road, I will tell you, and you will tell me whether you think it would be pretty or not.”

“ Look at this old tired soldier stopping beside the well, and the little girl holding up a tin can that she has just filled. Now he is stooping to drink, and she is putting back her hair off her forehead, and the setting sun full on her face. Would not this be a pretty Bewick?”

Her father, who had now finished what he was reading, and who was always cheerful and sociable, put away his book, and, looking out of the window, joined with Lucy and her mother in their diversion. Presently he saw an old man and woman trudging together down a lane that led to a wood, and he began to sing a favourite song of Lucy's, in which she immediately joined :

“ There was an old man who lived in a wood  
As you may plainly see,  
He said he could do more work in a day  
Than his wife could do in three.

“ With all my heart, the old woman said,  
If you will me allow,  
You shall stay at home to-day,  
And I'll go follow the plough.”

Harry turned about, and looked much discomfited by the singing, and Lucy said :—

“ Join us, Harry, oh ! join us, you know it.”

But Harry replied only by stopping both his ears, and hanging again out of the carriage window further than before. The singing in full glee was continuing, when Harry drew in his head, and, rubbing his hands, exclaimed, as he threw himself back in his corner—

“ I have it ! I have found it out, papa !”

His father did not ask what he had found out, but went on singing.

“ Father,” said Harry, “ will you explain to me now what is meant by a patent, or by taking out a patent for an invention ?”

“ I am singing, do not you hear ?” said his father. “ Go on Lucy, go on singing with me.”

When they had finished the song, Harry asked his question again, about the patent for an invention, but his father did not listen to him.

“ Papa,” cried Harry, after eagerly waiting for the moment when, as he thought he could fix his attention ; “ I want to tell you what I have been thinking of all this time.”

“ I do not want to hear it, Harry,” said his father, “ I cannot turn my mind to what you are thinking of ; I will go on with my own thoughts.”

So saying, his father put himself into Harry's late position, hanging over the side of the carriage.

“ Well,” said he, at last, turning to Harry, who looked doleful, “ you feel how unpleasant it is not to have people ready to sympathize with you ; you feel how disagreeable it would be to you, if we could not turn our thoughts to what you are thinking of, when you wish for our attention.”

Harry, looking ashamed, said, “ That is true, papa, I believe I have been all day very disagreeable ; but I did not mean it ; I was thinking of something that I hoped you would be pleased with, and I did not like to leave off till I had quite invented it, or at least made it as good as I could.”

“ Oh ! papa,” said Lucy, “ may I speak ? You ought to be pleased with his going on persevering through all the noises we made, and every interruption. I am sure I could not so have fixed my attention.”

“ You and your brother, my dear Lucy,” said her father, “ have two opposite faults, and I wish you both to know them, that you may take care and use your power over your own minds to cure them. Your attention, Lucy, passes too quickly from one thing to another. You are what is vulgarly called birdwitted. You should endeavour to prevent your mind from flying off from one subject to another : I encourage you to fix it as steadily, and as long at a time as you can. You are of such an affectionate, sympathizing temper, that there is no danger that you should not be

ready enough to turn your thoughts to the pursuits and amusements of others, whenever it is necessary or agreeable. You, Harry, have acquired the power and habit of fixing your attention steadily on your own pursuits, but you cannot easily turn your mind from your own thoughts to what is going on near you, or to what other people wish you to think of. Now consider, that your sister, and your mother, and I, and every body like sympathy, as well as you do probably; and if you acquired this unsociable habit of never joining in what we are doing, or being interested in what we are saying or hearing, you would become a very disagreeable companion."

"I hope I shall not," said Harry, with a look of serious alarm.

"You have perseverance and laudable ambition enough," continued his father; "but the danger for you is, that you should confine your attention too much to one small circle of objects, and not enlarge your mind by general observation and knowledge. You perceive, that I speak to you, not as to a foolish child, but as to a reasonable creature, who is desirous to improve himself. On this journey you will have opportunities of curing yourself of this fault. When you are going through a new country, look about you, observe every thing. When you are with people who are talking on subjects that are new to you, listen to

what they say. Much knowledge and amusement can be gained by the ear as well as by the eye. 'Ears and no ears' might make a good tale as well as 'Eyes and no eyes.'"

"He did listen the other day, papa," said Lucy, "and heard what the gentleman told about the wreck and the gunpowder: Harry repeated it to me afterwards."

"As he was so well rewarded by hearing what was entertaining, and by your remembering it so kindly," said her father, "I hope he will continue to attend to conversation."

"If people did not talk so much nonsense generally, in company, sir," said Harry, "I should listen oftener."

"Pick out the sense: if you try to do so, you will always find some golden grains of sense even in an ocean of nonsense. And suppose you should not, it will be of use to your own mind to interrupt, even by nonsense, the course of your thoughts. The mind becomes stupified, when it has thought too long on any one point."

"True," said Harry, "so I found to-day, when I was thinking about my measuring wheel. When I had thought and thought for a great while, I grew quite tired and stupid, I could not tell what was the matter with me; I could not invent what I wanted; and listening even to the mosquitoes, which I hated at the time, did me good."

“Harry is so candid,” said his mother, “that there is really some pleasure in finding fault with him.”

He was not like those foolish boys who, when they are told of any fault, think only how soon the person who is speaking will have done, that they may get rid of the immediate pain. Nor was he one of those who think only of what excuse they can make. Nor yet was he one of those (the most foolish) who grow sulky, and sit or stand like statues, feeling all the time as if the night-mare prevented them from stirring. It is true that Harry was acquainted with this disagreeable sensation, arising partly from shame, and partly from pride; but he struggled against it, and threw it off as soon as possible.

“Lucy, what were you doing before all this began?” asked Harry.

“We were singing the ‘Old Man in the Wood,’” said Lucy; and then she added, in a whisper, “should you like to sing it again? If you would, I will begin it.”

“I should,” said he, “begin.”

She began, Harry followed, and their father immediately joined them. They sung but badly, but they were all well pleased with each other, and Lucy said she was now *quite* happy.

“There must be some *nonsense* mixed with wisdom now and then, must not there, papa?” said she, “or else one is apt to grow terribly tired.”

ETRURIA.

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OUR travellers next arrived at Frankland Hall, in Staffordshire, where they were to spend three days with their friends, Mr. and Mrs. Frankland.

The first day at dinner, an old gentleman observed that the pie dishes of Wedgwood's ware were good contrivances for keeping vegetables hot, and remarked how very like real pie-crust one of them looked.

Mr. Frankland, who had been an intimate friend of the late Mr. Wedgwood, said that he was present the first day when one of these imitations of pie-crust appeared at dinner: the children of the family did not mistake it for a real pie, and Mr. Wedgwood had new ones made repeatedly, till at last one appeared so perfect, that at a little distance it could not be known from pie-crust. "When I took off the cover," said Mr. Frankland, "the child next me was agreeably surprised to hear it jingle on the dish."

"Besides this," said the old gentleman, "Mr. Wedgwood made a number of little every-day useful contrivances; for instance, that dish, in which there is a well for the gravy. In the olden

times, unhappy carvers were obliged to poke under the heavy sirloin for gravy, or to raise and slope the dish, at the imminent hazard of overturning the meat, and splashing the spectators. Knife, fork, spoon, slipping all the while, one after another, into the dish! And, ten to one, no gravy to be had after all! Nothing but cakes of cold grease. But now, without poking, sloping, or splashing, the happy carver, free from these miseries of life, has only to dip his spoon into a well of pure gravy. Thanks to the invention of one man, all men, women, and children may now have gravy without stooping the dish. So I give you, gentlemen and ladies, for a toast, ‘The late Mr. Wedgwood, and the comforts of life.’ ”

After he had drank his glass of wine, the old gentleman continued speaking :—

“I remember that Mr. Coxe, the traveller, was pleased by meeting with a beautiful service of Wedgwood ware in Russia. I dare say he might find one now in Siberia. Last year, when I was in Holland, I learnt that, even the town of Delft, which, for many years, used to furnish all Europe with crockery, is now supplied from England with our Staffordshire ware.”

The conversation next turned on China, and Chinese artists.

“They are very exact,” said Mr. Frankland, “in imitating whatever is bespoken from them,



but sometimes they carry this to a degree of provoking stupidity.”

Of this he gave an instance. A lady wanted to match some of the plates of a remarkably handsome service of china, which had been given to her husband by the East India Company. She sent a pattern to China, and bespoke some dozens to be made exactly the same. In due time they arrived, were unpacked, but, to her surprise and mortification, the lady found that every one of the new plates had the appearance of a crack across it; and, on examining the plate which had been sent as a pattern, it was found that there was a crack in it, which had been exactly imitated.

Even Harry, though he loved exactness, thought this was too much.

Lucy observed the beauty of the dessert china. On her plate there lay, or there seemed to lie, a convolvulus: it looked so natural, that she thought she could take it up. On her mother's was a Celsia, a geranium on another, and on Harry's a honeysuckle, of which she could almost fancy that she smelt the perfume. Even as she eat her ripe peach, she paused to examine these flowers. She thought it the most beautiful china she had ever seen. When she went into the drawing-room she saw on the chimney-piece flower-pots of the most delicate blue, with white figures on them, embossed like ivory, and exquisitely carved. The

drapery on the figures was so light, that it seemed as if blown by the wind, and so transparent, that she could see the blue ground through it.

Mrs. Frankland came to Lucy, as she was looking at these flower-pots, and told her that they were Wedgwood's ware, as well as the plates which she had admired at the dessert.

“Wedgwood's ware!” repeated Lucy. “I thought that Wedgwood's ware was always black or cream-coloured, such as tea-pots and the common yellowish plates.”

Mrs. Frankland told her there was a great variety of Wedgwood's wares. She took her into a cabinet at the end of the drawing-room, where she showed her several vases, made in imitation of antiques, which had been dug up from the ruins of Etruria, in Italy, and thence called Etruscan. Some had red grounds, with black figures; others red figures, on black grounds; others, which were called jasper, were very valuable. After Lucy had examined and admired all these, Mrs. Frankland said she would show her another, which was more valuable than all the rest. The original, from which it was exquisitely imitated, cost the present possessor four thousand guineas. As she spoke she opened the case which contained the vase, and carefully raised it from its crimson-cushioned bed.

“I know it, I have seen it before, mamma,” exclaimed Lucy.

“Seen it before, Lucy!” said her mother. “Where?”

“In a book, when I was reading to you, mamma.”

“You mean, that you have seen an engraving of it,” said her mother.

“Yes, mamma, you remember the three views in the Botanic Garden, of a vase just like this, with a dark ground and white figures. I cannot recollect the name of it, but I know it was dug up out of ruins.”

Her mother told her it was called the Barberini, or Portland vase. *Barberini* from the name of the Italian family to whom it had belonged; and *Portland* from the Duchess of Portland, by whom it had been purchased and brought to England.

Lucy, whose memory was now awakened, recollected Dr. Darwin’s beautiful lines addressed to Mr. Wedgwood, “Oh friend of art!” but she refrained from repeating them, for which Harry gave her credit due.

Mr. Frankland, who now came into the room, told her that the ancient Etruscan, or Greek vases, were produced by a different process from that which Mr. Wedgwood used in making his. They appear to have been made by covering the parts representing the figures and ornaments, after their outlines had been traced, and then dipping the

red ware in a black paint. The lines of the drapery, &c. were afterwards traced in the same colour. In those ancient vases, the colour, which was red, was in the *body* of the ware itself. In Mr. Wedgwood's imitations, both the red and black are painted *on* the porcelain, or rather on the *biscuit*; the name which is given to the ware after its first baking in the furnace. He was the first person who made what are called dry colours, or enamel, without lustre, without shining.

Harry thought that the smoothness and polish of these vases was more beautiful than any glazing.

"And much safer, and more durable," said Mr. Frankland. "These colours cannot be injured by damp, or fire, or air, or acid, and will last as long as the substance itself. You may have observed, that the glazing on common earthenware runs into little cracks."

"Yes," said Lucy, "I have often observed them covering a plate, like network. They look very ugly."

"But what is much worse," continued he, "in most kinds of glazing, lead is employed, which, when dissolved in certain acids, is poisonous."

Lucy observed, that *glazing* looked something like *glass*, and from the sound of the words too, she believed *glazing* came from *glass*. It might at first have been called glassing."

"Yes," said Mr. Frankland, "and there is, as

you observe, a resemblance between the outside of some porcelain and glass. But the difference between glass and porcelain is, that porcelain is but *semivitrified*, that means half turned to glass. The managing the heat so as to stop the vitrification, or turning to glass, at the right time, is one of the most important points in making porcelain."

Lucy returned to admire the beauty of the Wedgwood's ware, repeating that she thought it much prettier than Chinese china.

"Besides the beauty of form, and colour, and texture," continued Mr. Frankland, "the utility is great. It is not only perfectly safe for all culinary purposes, but most durable for some chemical experiments, in which the vessels must be exposed to great heat."

Mr. Frankland showed them a crucible and a retort, made of Wedgwood's ware, and Mrs. Frankland showed a white pestle and mortar, which looked like marble, but which was of Wedgwood's ware, and used for pounding medicines.

Harry asked whether the potteries, where all these were made, were near Frankland Hall.

"Yes, within a few miles of us," said Mr. Frankland, "at a village to which Mr. Wedgwood gave the name of Etruria, and where he established a manufactory, whose productions are probably more known, and more useful to a greater number

of people, than ever were those of the ancient Etruria.

Mr. Frankland said, that he would the next day take Harry and Lucy to see these works. In the mean time, as Harry seemed anxious to know more, he told him all that he thought could interest him, concerning the history of the Staffordshire potteries. The clay of this part of England being fit for making some kinds of earthen ware, there have been potteries, or remains of potteries, in Staffordshire, ever since the time when the Romans were in Britain ; but they had continued in a rude state for ages, as no person of industry or knowledge had attempted their improvement, till, about a hundred and twenty years ago, when two brothers of the name of Elers came from Holland, settled here, and manufactured a red unglazed porcelain. Afterwards they made a sort of brown glazed stone ware, coarse and heavy, yet the glazing of these, such as it was, could not be performed without great inconvenience. They used salt, which they threw into the oven at a certain time of the baking of the vessels. The fumes from this were so odious, that the neighbourhood were alarmed, and forced the strangers to abandon their potteries, and quit the country. Soon afterwards, a workman, who had found out the secret of their mode of glazing, for even that was a secret, pursued the same method in a pottery of his own ;

and this was suffered to go on in spite of the nauseous fumes, because the inhabitants found the jars they made so useful for holding their butter. They were employed chiefly for this purpose, and the manufactory was called the Butter Pottery. On glazing days, however, the nuisance was terrible, the offensive fumes spread to a distance of six or seven miles. Thick clouds from these furnaces rose over the hills, and filled the valleys with their dense vapours.

The first great improvement in our potteries was made in the substance of the ware itself, by introducing ground flints into the composition, and then was made what is still called white stone ware. It is used for many purposes. You may have seen it, for instance, for Seltzer water bottles."

"I know what you mean," said Lucy.

"This was the safest and best ware we had," continued Mr. Frankland, "before Mr. Wedgwood's time. It is said, that the first idea of using powdered flints was suggested to a poor Staffordshire potter, by accident."

"By accident! I am glad of it," said Lucy. "I like to hear of discoveries made by accident, especially by poor people."

"There was a Staffordshire potter, whose name is forgotten, or whose name I forget; he stopped on a journey to London, at Dunstable, in Bedfordshire, where the soil is flinty and chalky. He consulted the hostler of the inn where he stopped

about some disorder in his horse's eye. The hostler advised that powdered flint should be put into the eye; and for this purpose he threw a flint into the fire to *calcine*, that is to burn it, that it might be more easily pulverized. The potter, who was standing by, observed the great whiteness of the calcined flint, and being an ingenious, as well as an observing man, immediately thought of applying this circumstance to the improvement of his pottery. He first tried the experiment of mixing finely powdered flints with tobacco-pipe clay; he succeeded to his hopes, and made white stone ware, which put all the brown and coloured stone ware out of fashion. Ugly as you think it, Miss Lucy, it was much approved, till Wedgwood came, and gave us something better—that cream-coloured ware, which was called queen's ware, because it was first patronized by Queen Charlotte. It was then, and not many years ago, prized in palaces; now it is used in every cottage, and known in every place where plates or dishes are to be found. After this queen's ware, he invented all the varieties which you have seen, and many more."

Mrs. Frankland rang the bell, and ordered the servant to bring a plate of cream-coloured Wedgwood ware, another of the white stone ware, a crock of the dark glazed kind, and a common red garden pot; these she placed in the order in which they had been made, beside Wedgwood's



beautiful vases, to show Harry and Lucy the difference and contrast.

“And all these improvements, or at least the greatest part of them, were made by one man,” thought Harry, “Then more was done by him during his life-time than had been done in hundreds of years before.”

Lucy asked if any lucky accidents had happened to Mr. Wedgwood, which put improvements into his head, or gave him the first idea of any of his inventions? She said, she should like very much to know the story of these, if Mr. Frankland would tell it to her.

Mr. Frankland said, he did not know of any such, and observed that, though one or two fortunate accidents might occur to the same person, it was not possible that such progressive improvements, as Mr. Wedgwood had made, could have been suggested by accident, or accomplished by any one who had not scientific knowledge.

“I should like very much,” said Harry, “to know what he did first, and what he did next, and how he went on from one experiment to another.”

“Of all this, I cannot pretend to give you a history,” said Mr. Frankland; “for I am not sure that I know it clearly myself. All I can tell you is, that he improved the potteries by the introduction of substances, which had not before been employed in the composition of these wares. It had been found, that some Cornwall granite is

as good for making porcelain of a certain kind, as the clay which the Chinese use. Mr. Wedgwood introduced Dorsetshire and Cornwall clays."

"Perhaps you could tell me, sir," said Lucy, "how the delicate blue of the ground of this flower-pot is made."

"That is given by a substance called cobalt," said Mr. Frankland. "But as you have never seen it, the word cobalt teaches you little."

"I wish I knew," said Lucy, "how the beautiful colours of the flowers on the dessert plates, and how the purple and rose colours on this cup are produced."

"The purple and rose colours are given by the precipitate of gold dissolved in nitromuriatic acid: the oxides of iron also produce many of the colours which you admired. But as you are not acquainted with any of the oxides of iron, or with nitric or muriatic acid, or with the precipitate of gold, you know nothing more from my answer than a number of names, which probably you will not be able to remember an hour, and which, unless you learn their properties, could be of no use to you, even if you could keep them in your head all your life."

"But without telling us all those hard names, sir," said Lucy, "could not you give us some general idea of how he did it all?"

Mr. Frankland smiled, and answered, that he did not exactly know what she meant by a general idea of it all. He could tell her only, that Mr.

Wedgwood in the first place learnt the properties of different clays and minerals, and what effect would be produced on these by fire. In short, he applied to the study of chemistry and mineralogy, to learn all the experiments which had been made by others, and then he tried new ones for himself; but if he had not read and acquired this knowledge first, he might have wasted his time and ingenuity in doing what others had done before him. Besides genius to invent new and elegant things, he had the good sense to observe what is wanted every day, by the greatest number of people; so that he not only produced what pleased persons of taste, but what was useful to all classes; and he continually considered how he could improve, not only what others made, but what he had himself produced. It was by this attention to little, as well as to great objects, and by steadily adhering to one course of pursuits, that he succeeded in accomplishing all that he began: no small praise for a man who undertook so much. "The consequences of his success we all know," continued Mr. Frankland, turning to Harry's father, "and we all rejoice in them. Wedgwood made a large fortune for himself and his children, with a character, a reputation, above all fortune. He increased amazingly the industry, wealth, and comforts of the poor in his neighbourhood; multiplied the conveniences, elegances, and luxuries of life for the rich; raised,

at home and abroad, the fame of the arts and manufactures of his own country; extended her commerce, and spread his own name, with his productions, to the most remote regions of the civilized world."

A pause ensued after these words: all looked with admiration at his works, and those who had known him intimately sighed for the loss of an excellent man and a kind friend!

The next day, Mr. Frankland took Harry and Lucy to see the works at Etruria. We shall not follow them through all the processes, but shall only mention what Harry and Lucy recollected and told their mother on their return.

"The first thing I remember," said Harry, "is the improvement in the way of grinding the flints."

"But you must know, mother, in the first place," said Lucy, "that formerly this was very unwholesome work, such a quantity of the dust of the powdered flint flew off; and, as the workmen breathed, it went in at their mouths, or up their noses, and it brought on complaints in their lungs and stomachs, and inflamed their eyes besides."

"All this was remedied," continued Harry, "by grinding the flints in water, which prevented the dust from flying off. The name of the man who made this improvement, and who made the first mill on this principle, was Brindley, and the mill is very ingenious."

"But you had better not stop to describe that,"

said Lucy, "because, perhaps, mamma does not care as much about it as you do. Now let me go on, Harry, and tell a little. Well, mamma, the flints ground in the great *caldron*—"

"Mill," said Harry.

"Mixed with water," continued Lucy, "looked at first like chalk and water, thickish; then by mixing with clay, and by stirring, and beating, and straining through sieves, this became first a sort of pulp, and then about as thick as paste or dough, and then it was ready for the man to carry to the potter's-wheel. You know the potter's-wheel, mamma? I remember first seeing the print of it in our book of trades. But there is an improvement in this. The very common one, which I once saw, long ago, was only a circular board turning on a perpendicular stick."

"Axis," said Harry.

"A boy whirled it round for the man, you know, mamma, while he went on moulding the clay upon it into a bowl, and he called to the boy to make it go slower or faster. But in this potter's-wheel no boy to whirl the board is wanting, for it is turned by a shaft."

"And that shaft is turned by a steam-engine," said Harry. "The steam-engine, mother, at work again; observe, mother."

"Yes," said Lucy, "papa called it the great servant of all work."

"But there was an improvement in this potter s-

wheel, which you have not told yet, Lucy," said Harry.

"No, no, but I am coming to it, let me tell it," said Lucy.

"If you understand it," whispered Harry, in a very kind tone, as he was only afraid for her, not anxious to show what he knew.

"I understand one thing about it, and that is all I want to tell, my dear," said Lucy. "But I will begin another way. You know, mamma, that it is necessary to make the potter's-wheel go slower or quicker, whenever it is desired by the man who is moulding the clay. Formerly this was done by a boy, who turned it faster or slower as he was bid; but the steam-engine, which is now used for keeping this wheel in motion, goes on continually at its own regular rate, and would never mind his calling out 'faster!' 'slower!' 'slower!' 'faster!' Therefore he must have some way of slackening or quickening the wheel, without interfering with the steam-engine. This is done for him by the new contrivance, which I will now describe to you, if I can.

"Imagine, mamma, two sugar-loaf shaped rollers; two cones of wood standing one with the point down, the other with the point up, and turning on pins run through them, like your silk winders: these cones are placed at some distance from each other, opposite to the potter's-wheel. Suppose that one of them is kept in mo-

tion by the steam-engine, and that this motion is communicated by a band to the other cone, by which the potter's-wheel is turned. Very well. Then next, mamma, imagine these cones to be so placed, that the band should always be at the thicker part of one cone, while it is at the thinner part of the other. Then, when the potter wants his wheel to go faster, he shoves up the band to the thinnest part of that cone which is connected with the wheel, and if he wants it to go slower he pushes the band on to the thicker part; something like the way, mamma, in which, as you may remember, we have seen old Margery with her spinning-wheel shift the band from the larger to the smaller rim of her wheel. Harry took notice of the cones as soon as he saw them, and asked what was their use. Papa bid him find out, and he did. Was not that well, mamma?"

"I am glad you remember this, my dear Lucy," said her mother.

"Thank you," said Harry's eyes.

Lucy went on with raised spirits: "Mamma, I wish you had seen the man moulding the clay, and all the metamorphoses of the potter's-wheel. First, in one minute, the lump of clay turned into a bowl; then, the instant after, he squeezed this soft bowl up in his hand, dashed it on the wheel, and again he turned, and moulded, and in an instant it was a plate! In another instant the plate was gone, and in its stead a cup stood before us!"

“A cup without a handle,” said Harry.

“The handle, if wanted, must be made separately, and stuck on afterwards. Only certain shaped things, such as plates, and cups, and saucers, things which are evenly round, are made on the potter’s-wheel. Those which are square, or which have *ins* and *outs* in their shapes, are made in moulds, into which the moist clay is squeezed; sometimes, two parts of a thing, the spout of a tea-pot, for instance, are made in separate moulds, and the halves joined together afterwards. But I dare say, mother, you know all this.

“I knew most of this myself before,” continued Lucy, “from the prints and descriptions in our dear book of trades, and from some others of our little and large books. But I liked to see the real work going on, and the real things. There was always some difference between the description and the reality, or something that I fancied larger or smaller than it is, or some little particular circumstance which I did not comprehend till I saw it. Mamma, I did not tell you, that we saw the furnaces and kilns, for baking—*firing* the porcelain, as they call it. These were much larger than I expected. When the porcelain has been once baked, it is called *biscuit*, in which state it is ready for painting. Mamma, I have not told you how much I was entertained in the painting room, by seeing how dull the colours look when they are first laid on, and how bright and brilliant they are



after they have been fired—what was to be gold, was quite dark beforehand.”

“ Pray, Lucy,” said Harry, “ did you observe a man who was standing beside one of the furnaces, whose business seemed to be to regulate the heat? He had some little bits of clay, which looked like little stoppers, and he put these into the fire and measured them, did you see how?”

“ No; I saw the man,” said Lucy; “ but I did not know what he was doing. Well, mamma, there is one other thing I remember, and that is all. You know the common kind of blue and white cups and saucers, and plates, with windmills, and houses, and strange Chinese looking figures, and all manner of things upon them?”

“ I do know luckily what you mean,” said her mother, laughing, “ otherwise I am not sure that I should know it from your description.”

“ Mamma, these were formerly painted, one at a time, by hand, but now there is a much quicker way; Mr. Frankland showed it to me. First, the patterns, whatever you wish, houses, or churches, or geese, or turkies, or shepherdesses, or elephants, or windmills, are printed on paper.”

“ *Engraved* on copper first,” said Harry, “ and the blue colour put upon the copper-plate, instead of printer’s ink.”

“ And the blue colour—oh! let me tell that, Harry!” cried Lucy; “ the blue colour is made of cobalt.”

“*Oxide* of cobalt, I believe,” said Harry, “which differs from cobalt, Mr. Frankland told us, if you recollect, Lucy, as much as rust differs from iron.”

“Well, oxide of cobalt it should be, I recollect,” said Lucy; “and this is mixed with some earth and—”

“And linseed oil,” said Harry; “like what is used in printer’s ink.”

“And when it is altogether about as thick and soft as paste, it is put on the copper-plate. You know, mamma, you showed me common engraving once: and just like any common engraving this is done. As many copies of patterns are taken off on paper as you want.”

“You forgot that the paper was smeared first with soft soap,” said Harry.

“Then, when you want to use these patterns,” said Lucy, “the printed part is moistened and laid on the cup, or whatever you wish to put it on.”

“The cup must be in the state of biscuit, remember,” said Harry.

“Biscuit, to be sure,” said Lucy; “the biscuit instantly sucks in, absorbs the colouring stuff, from the moistened pattern; then the paper is washed off, and you see the coloured pattern printed on the cup directly. Is not that nice and quick, mamma? Then the cup must be let to dry, and afterwards it is dipped in some sort of glazing stuff, and the cobalt, I mean the oxide of cobalt, comes out a beautiful blue. And there is the cup

finished, painted in this easy, expeditious way: a hundred thousand, I dare say, could be painted in this manner, while a person could paint one single cup in the old way."

"The name of the ingenious person, as Mr. Frankland said, who discovered this method of transferring engraving from paper to earthenware, has not been preserved, and I am sorry for it," added Harry.

"Mr. Frankland told us that, since this invention, this blue and white ware has been made in such quantities, and so cheap, that now almost every body can afford to buy it, and it is in every cottage; and the poor people can have now, what only the rich and grand had formerly. Are not you very glad of that, mamma?"

"Yes, I am, my dear," said her mother; "and I am glad," added she, smiling, "that you give yourself time to take breath at last, and that you allow me time to thank you for all you have told me. You seem to have been very much entertained at the potteries, and you have entertained me by your account of them."

"Mamma," said Lucy, "do you think we have remembered enough? I know I cannot recollect half what I saw and heard, but I remember almost all that I understood clearly."

"That is quite enough, my dear," said her mother; "I never wish you to remember more than you understand. Of what use could it be?"

PYROMETER.

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“GOOD morning to you, mamma,” said Lucy. “I forgot to tell you yesterday, when we were talking about the potteries, that we saw the house in which Mr. Wedgwood formerly lived; and a very nice house it is.”

“Good morning to you, father,” said Harry. “Do you recollect yesterday seeing a man standing by one of the furnaces measuring some little stoppers of baked clay, which he slid in between two pieces of brass, like the two parts of a hinged ruler? These pieces of brass were fixed, but not parallel to each other; they were closer together at one end than at the other. The man took the bits of clay, or stoppers, out of a heated furnace, and he tried each stopper between these rules, and looked at divisions, which were marked on the brass plates. What was he doing, papa?”

“He was using a sort of thermometer, Harry,” said his father.

“A thermometer of clay, papa!” said Lucy.

“Yes, for measuring higher degrees of heat than can be shown by that thermometer which you have seen; if that were exposed to heat be-

yond the highest degree marked on its scale, the quicksilver would expand, so as to burst the glass, and the glass would melt, if put into one of those furnaces which you saw yesterday; but these clay thermometers can bear, and can measure the heat of the fire; for which reason it is called a *pyrometer*, that is, measurer of fire heat."

"I am glad I know the name, and what it means," said Lucy.

"Father," said Harry, "will you be so good as to explain the pyrometer to me?"

"Harry, will you be so good as to use your own understanding?" said his father. "From what you have seen, and from what I have just told you, you know enough to comprehend or invent the rest, without any further explanation from me."

Harry was silent, and considered first its use. He had seen the man put the stopper into the furnace, and then measure it between the rulers, and afterwards say to another workman—the man who was feeding the furnace, "This heat will do." Now, thought Harry, what change could have been made in the clay, after it had been put into the furnace, and how did he measure it, when he pushed it in between the two rulers? He must have been trying whether it had grown larger or smaller, after having been put into the fire.

"I think," said Harry, "that perhaps some sorts of clay either shrink or grow larger, when

they are put into the fire. If they did so always regularly, and if people found this, after a number of trials, then they might know the heat of the fire by the quantity which the clay had shrunk, or increased in size. If this is the case with those bits of clay that I saw, they would be pyrometers, or measurers of fire heat, as you said; I mean if you had the degrees marked upon the ruler to measure them."

"Exactly so," said his father, "you are right, as far as you have gone; still there is a part of the pyrometer which you have not explained to me. You observed that the rulers were not parallel to each other: do you think that was done by accident, or on purpose?"

"I think it must have been on purpose; they seem to have been screwed down on the plate firmly, like a rule partly open."

"Then, if they were placed so on purpose, for what purpose?" asked his father.

"That the different degrees of shrinking might be measured as the stoppers are pushed in," said Harry. "The person who first made the pyrometer must have tried experiments, and must have marked the different degrees which the clay shrinks with different heats. But I do not know by what parts of an inch, or by what scale it is made. The rulers seemed to me to be about two feet long."

"They are," said his father, "and the opening

at the widest end is five-tenths, and at the narrowest three-tenths of an inch. And so that this proportion is kept, it does not signify what inches or feet may be used in the length of the rulers. The bits of clay which you saw exactly fit into the widest opening before they have been used, and they shrink according to the degree of heat to which they are exposed, if it is greater than that in which they were first slightly baked."

"Then, papa, they can only show a greater degree of heat, not a lesser, and if they do not swell out again to the former size, they are of no use after they have been in a great heat," said Lucy.

"Of none," replied he, "fresh stoppers must be continually used."

"That is a great inconvenience," said Lucy, "because you must drag about this weight of stoppers. Not like a nice portable thermometer in its little case."

"But it has so many conveniences, Lucy," said her father, "that we may well pardon that one disadvantage."

"One great convenience I see," said Harry; "the stopper always remains of the same size, after it is taken out of the fire, so that there is no danger of making mistakes about it; you may measure it over and over again: but the quicksilver varies, so that if you do not write down the degree accurately, you are undone."

“This pyrometer,” continued his father, “is chiefly used in manufactories, or by chemists, in their laboratories. It has been of great use to Mr. Wedgwood, who made it, from feeling the want of such a measure in his potteries. It was necessary that he should know at what heats certain clays melt or *vitrify*, that is, you know, turn to glass. The common workmen’s expression for this, such as *red heat*, or *white heat*, he found so inaccurate, that, in trying experiments, many things were spoiled for want of that exact measure which his pyrometer now gives. By it, he has ascertained what heat all kinds of porcelains can bear, without breaking, or melting, or turning to glass. What is of still more use, he can ascertain the exact degree of heat required for baking, or, as they call it, firing any kinds of porcelain or earthenware, of which he could obtain any specimen, whether made in this, or in foreign countries. As Mr. Wedgwood said in describing it, it speaks the language of all nations. The advantage of having an accurate universal measure, in any case, much as it pleases you now, will please you more when your knowledge enlarges, and when you see the further uses to which it can be applied.”

“Papa, I remember seeing,” said Lucy, “in ‘Scientific Dialogues,’ the description of a pyrometer, but I do not think that it was made of clay.”

“No, that pyrometer is different,” said her



father ; “ that measures by the expansion of metal bars with different degrees of heat, which is shown by the motion given to an index.”

“ Like the hygrometer,” said Lucy.

“ Yes, and there are several different kinds of pyrometers, of which you can read the description at your leisure,” continued her father, “ in any encyclopædia, if you have any curiosity about them.”

“ Yes,” said Harry, “ I should like to compare them, and see which is best, if I could.”

“ That would be a good exercise of your judgment, Harry,” said his father ; “ but there are so many they might tire and puzzle you.

“ The clay of which Mr. Wedgwood’s pyrometers are made,” continued his father, “ possesses some properties, which fit it peculiarly for the purpose to which it has been judiciously applied. Those half-burnt bits of it, which you saw, Harry, may be dropped at once into intense fire, without cracking ; and, when they have received its heat, may be plunged into cold water without the least injury. In about three minutes they acquire all the heat from any fire, which they are capable of receiving, so as to contract as much as they ever will from that degree of heat. They may afterwards be left in that heat as long as you please, for they will not change. Take them out, and they can, as you have seen, be cooled in a few

seconds, and are then ready for measuring in the gauge, or scale."

"How very convenient!" said Harry. "But as each pyrometer-bit can be used but once, there ought to be a constant fresh supply."

"There are large beds of this clay in Cornwall," said his father; "and to ease your mind, Harry, on this subject, I can tell you, that Mr. Wedgwood offered to give the Royal Society a sufficient space of a bed of that clay, to supply the world with pyrometer pieces for ages."

"I like that very much," cried Lucy. "I cannot bear that people, who discover scientific things, should be covetous of them, or afraid that others should have a share."

"How could you ever think of such a thing?" said Harry.

"I never should have thought of it," said Lucy, "only that I heard a gentleman once at Aunt Pierrepont's say—but I believe I had better not tell it, because it can do no good to any body. But Harry, I hope, and I am sure, that if ever you invent or discover anything, you will be ready to let others share with you."

"That I will," said Harry; "Oh! I wish it was come to *that*. Father, there is something else I want to say, but I do not know how to express it. It is, that I think that a person who invents any pyrometer, or hygrometer, or barometer, or

new and exact instrument for measuring heat, or cold, or height, or quantity, does more service than a person who invents only a machine, which will do only for some particular purpose : because those measuring instruments will assist a great many other people in their experiments, for years, perhaps for ages to come. Do you understand what I mean, papa ?”

“ Yes, my dear, and I think what you say is very true. But do not twist the poor button of my coat any more, or you will pull it off; and let me go now, for there is the breakfast bell.”

“ Who will be down stairs first ?” cried Lucy, letting go her button, and running foremost. Harry might have overtaken her perhaps, in a race across the hall, but that he stopped to hold open a swing door for Mrs. Frankland. She had in her hand two small packets, one of which she gave to him, and the other to Lucy. On opening the papers in which these were wrapped, they each found a cameo of Wedgwood’s ware. Lucy’s, which was black on a white ground, represented a negro in chains, kneeling with his hands raised, in a supplicating manner, with this motto engraved,

“ Am I not a man and a brother ?”

Harry’s cameo was all of one colour, brown. It represented three allegorical figures, Peace, Art, and Labour; and it was made of clay, which had

made use of this clay, as Mrs. Frankland told Harry, on purpose to show the settlers and inhabitants of that country what could be made of their materials by industry and ingenuity; and thus he encouraged them to exert themselves. Of these cameos the late Mr. Wedgwood distributed many hundreds. And no doubt considerable effect was produced by

——“the poor fettered slave, on bended knee,  
From Britain’s sons imploring to be free.”

THE GARDEN.

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“Lucy, you have not seen our garden yet,” said Mrs. Frankland. “We had not time yesterday, but if you are fond of a garden come with us now, your mother and I are going there.”

“Oh! thank you ma’am,” said Lucy; “but I must call Harry, and we will follow you directly.”

They followed, and a gay garden it was, full of a variety of bright-coloured flowers, rich beds of carnations, and roses in full blow.

“Roses, moss roses in full blow in September!” cried Lucy. The day before she had left home, she had searched their garden for a rose for her mother, but could find only one poor solitary bud, which had a yellow nightcap on. She asked Mrs. Frankland to tell her how she contrived to make her roses blow so late in autumn.

“By pulling off some of the buds in spring,” said Mrs. Frankland, “as soon as they begin to form; and by transplanting some of the rose trees early in the spring, so as to prevent them from flowering at that time, then they blow in autumn.”

Lucy said, she would try this on her own two rose trees next spring.

“Not on both, will you?” said Harry. “Let us pull the buds off one, and leave them on the other, then it will be a fair experiment.”

“And besides, you may then have a chance,” said Mrs. Frankland, “of the first rose of spring, as well as the last rose of summer.”

Lucy took notice of some large clusters of bright blue flowers—agapanthas, and varieties of dahlias: she thought them beautiful, but she supposed that these could not be had without a great deal of trouble and money, and a hot-house, or a gardener at least. But Mrs. Frankland said these did not require a hot-house, or even a gardener’s skill. “Indeed,” said she, “all the flowers in this garden, excepting perhaps certain carnations, which my gardener prizes highly, though I do not, may be had by anybody with a little care and exertion of their own.”

“By anybody!” repeated Lucy. “But, ma’am, do you mean bodies like us? like Harry and me? with only our own hands?”

“Yes, bodies like you,” said Mrs. Frankland, “with your own hands, provided you use your heads as well as your hands.”

“In what way must we use our heads?” said Lucy; “will it be very difficult?”

“No, consult your gardener’s dictionary, and follow its directions. Only remember to do so at the right time of year,” said Mrs. Frankland. She

told Lucy that she would give her the root of an agapantha, and of some dahlias, and that she and Harry were welcome to seeds, roots, cuttings, or slippings, of anything they liked in this garden. "Write down what you wish, and I will have them ready by the time your mother brings you here again, as I hope she will on your return homewards."

Joy sparkled in their eyes, and they thanked Mrs. Frankland, with warm gratitude; but, an instant afterwards, they looked unusually grave; for the embarrassment of riches came upon them. They were left to make out their list; and how to choose was the difficulty, where all were beautiful, and when their little garden could not hold all. Harry went to work prudently. He measured out a space of ground, that was the size of their own garden. Lucy could hardly believe that it was so small as what he now showed her; but he had often stepped the boundaries, and was sure of the size of their territories. Rule and measure soon settled the affair, and brought their wishes into proper compass. They calculated what their garden would hold, and made out their list accordingly. Their chief wish was to have a great bed of pinks and carnations.

But the moment they went near these, an old gardener, who was at work in the garden, and who had long been eyeing them, approached.

He began to praise his carnations, which he said were the finest in the county, and he pointed out his favourites. There was the Prince Regent, and the Duke of Wellington, in full glory, these every body knew; but beyond these, he had two superlative new favourites. One he called, *The pride of Holland, or the grand Van Tromp*. The other, *The envy of the world, or the great panjandrum*. Harry and Lucy did not much admire either of these. Van Tromp they thought was of a dull colour, and the great panjandrum had burst, and was falling to pieces in spite of his card support. Harry preferred some others.

“That which you are now at, master,” said the gardener, “is Davy’s Duchess of Devonshire; that little duchess was thought a great deal of some years ago, but she is quite out of fashion now.”

Harry did not care for that, he liked her.

“What does he say?” asked the deaf gardener, turning to Lucy, and leaning down that he might hear the answer.

“I say,” cried Harry, speaking loud in his ear, “that I like my little duchess better than your great panjandrum.”

“Indeed!” said the gardener, smiling in scorn. “Why, master, what you have taken such a fancy to is not a carnation even, it is only a pink.”

“I do not care,” said Harry, “what you call



it. I like it, whether it be called carnation or pink."

The gardener looked at him with contempt.

"Pray what is the difference between them?" said Lucy; "my mother has told me, but I forget it."

The gardener told her, that one chief difference is in the roundness of the petals of carnations, and the jagged or pinked edges of the petals of pinks.

Lucy liked these edges, and she really thought some of the pinks prettier than the carnations. She told Harry so, in a low voice. "But I am afraid," said she, "that the gardener would despise me if he heard me say so."

"What signifies whether he despises you or not?" said Harry. "There is nothing wrong in liking a pink better than a carnation."

The gardener, who did not hear what was said, fancied that they were debating whether they should ask for one of his grand panjandrums, and he began to say, that he was sorry that he could not offer this, he could not give this to anybody.

Harry assured him that he need not make any apology, because they did not wish for them. Piqued by Harry's indifference, the gardener named several lords and ladies who had admired his panjandrum above all things, and who had tried in vain to obtain it. It was a very great

rarity, he said. Only two other people in England had a real panjandrum.

Harry liked flowers for being pretty, and did not care whether they were rare or not.

The gardener did not believe him. Soon afterwards he offered Harry some pinks, of a kind which he liked particularly.

“But, master, I can let you have them only upon condition that you promise not to give any cuttings or layers of them to any one.”

Harry drew back with disdain, and said he would make no such promise.

The gardener said, that unless he would he should not have the pinks.

“Then,” said Harry, “I will do without them.”

He turned off abruptly, and walked away, but Lucy stood still, and said,

“I believe we may have them. Mrs. Frankland told us we might have anything in this garden that we choose; and here she is coming back from the orchard.”

“Oh! that alters the case,” said the gardener, with a look of some mortification. “Then, master, you must choose what you will, to be sure.”

Harry turned back, and walked composedly along the sides of the carnation beds, writing down the names of those he chose on a bit of paper. The gardener breathed freely, when Harry

passed by the Pride of Holland, and turned his back upon the Envy of the world.

Lucy whispered to her brother, "Did you see how much he was afraid that you should have chosen any of those that are really valuable; and why did not you?"

"Because I did not like them, and I despise his mean reasons for liking them," said Harry, putting the paper and pencil into her hands. "Now go, Lucy, and choose."

Lucy, admiring her brother's independence, followed his example, and chose what she liked, without being influenced by the foolish wish of possessing what other people cannot procure. She did not choose either the Pride of Holland, or the Envy of the world.

Harry was quite right to adhere to his own taste: here was no trial of complaisance or generosity.

Mrs. Frankland and their mother now returned from the orchard, and Harry and Lucy gave Mrs. Frankland their list. She looked it over, said she thought they had chosen well, and had been moderate in their requests. She called to her gardener, gave him the paper, and desired him to have the plants in readiness at the time she mentioned.

"Very well, ma'am," he answered, coolly looking over the list, which he saw was only of

common flowers; but when she added, that he must also give some Dutch hyacinths and tulip roots, the gardener's whole countenance changed, he exclaimed, "My Dutch tulips and hyacinths!" and throwing down a hoe that he had in his hand, he walked off, muttering to himself, "that it was well his mistress's head was not loose, or she would give it away."

Mrs. Frankland laughed good-humouredly at his anger. She bore with him, she said, because he was an old and faithful servant, who had been long in the family before she was married. "Though you might not think it," said she, "he is generous to his relations, of all that belongs to himself, and covetous only of what belongs to the garden, of which he considers himself as guardian against his mistress's extravagance. But I cannot bear this sort of petty avarice and rivalry about flowers, in persons whose education ought to have raised them above such illiberality. I have heard of a lady, who, when she was asked by a friend for the roots of some particularly fine flower, ashamed to refuse, yet unwilling to give, boiled the roots before she sent them, to prevent the possibility of their growing."

Harry expressed the greatest indignation against this meanness.

They now entered the conservatories, and observed the flowers of a plant which hung over

the entrance of the peach-house. They looked as if they were cut out of thick velvet, and were covered with honey. Their smell, which had been pleasant at first, soon became disagreeable and overpowering. Mrs. Frankland told Lucy, that this plant is called *Hoya carnosa*; *Hoya* from the name of Mr. Hoy, the gardener, who introduced it into England; and *carnosa* from the fleshy appearance of the flower. She had planted it at the door of the peach-house, because it is there a useful guard. Wasps are so fond of its honey, that they will, for this, leave untouched peaches and grapes. After they had seen the peach house, they walked through the conservatory, where Mrs. Frankland pointed out a tree, called the Papaw tree, *carica papaya*, which had been brought to her lately from the West Indies. The gentleman who gave it to her told her, that it will grow twenty feet in three years; that its juice has the singular property of making meat tender; if the juice be rubbed on beef it makes it as tender as veal; if an old fowl be hung on the trunk of this tree, it becomes, in a few hours, as tender as a young chicken. This, it is affirmed, is a fact which has been long known to those who have resided in the West Indies. But Mrs. Frankland said, as she had not yet tried the experiment, she could not assert it to be true.

At this moment, Harry put his hand to the

mouth of one of the flues of the pipes in the conservatory, and perceived that warm air came through it; but Mrs. Frankland told him, that this air was not well heated, and therefore did not heat the building as it ought. She said, that a man was just going to alter, and she hoped to improve them. Harry heard his father talking to this man at the other end of the conservatory, and he went to see what was doing.

His father turned to him, and asked, whether, if *he* were to place the pipe, he would put it at the top or the bottom of the building?

Harry answered, "At the bottom; because I know that heated air is lighter than air that is not heated, and therefore, if it is let in at the bottom of the building it will mix with the colder air, and gradually warm the whole house as it rises to the top."

As Lucy walked on with Harry, she asked him how he knew that hot air is lighter than cold.

"As you might know," said Harry, "if you recollect a diversion we were fond of when we were children, and which I should like this minute." He puffed out his cheeks, and blew through his hand, as he turned his face up towards the sky.

"Blowing bubbles, you mean!" said Lucy; "but what then?"

“What do you think makes the bubble go up?” said Harry

“It goes up, because it is lighter than the air.”

“And how comes that? What is it filled with?”

“It is filled with air from the mouth, blown through a tobacco-pipe.”

“Well, whether it is blown through a tobacco-pipe or not,” said Harry, “is the air from your mouth hotter or colder than the outer air, do you think, when the bubble rises?”

“Oh! hotter to be sure; now I know what you mean. The bubbles go up, because they are filled with heated air. Indeed I might have known from this, that heated air is lighter than cold air; but I did not recollect it at the right moment. I wonder how you came to remember it so well.”

Harry said, that besides the bubbles, another thing fixed it in his mind. A thing which he had seen when she was away from home. A fire balloon, which went up because it was filled with heated air. He was one of the persons employed to hold the great bag of the balloon over a fire made of straw. “It was all flaccid at first,” said he, “as my father called the bladder which you may remember he showed us.”

“Yes,” said Lucy; “and if your balloon were filled with heated air, it would expand. I know that.”

“ Yes, but you do not know how it pulled,” said Harry. “ I felt it beginning to pull against my hands, as it filled out ; and at last, when it was quite full, it pulled so hard that I could scarcely hold it. But I was desired to hold fast, and I did, though my knuckles were burning. The instant papa cried ‘ Let go,’ we all loosed it, and up it went, to a great height, quite into the clouds. Oh, the pleasure of seeing it go up ! and the pain of my knuckles, which were all blistered, fixed the whole in my mind, so that you need not wonder at my remembering it.”

While they were talking in this manner, their father was still speaking to the workman about the stove of the hothouse. They joined him, and listened to what he was saying. The man was asking Mr. Frankland if he had seen the new method of heating houses, used in a neighbouring town. He had, and admired it much. It had been first attempted at the house of the gentleman by whom it had been invented, which it warmed most comfortably. Then it was tried at the County Infirmary, where it also succeeded to the satisfaction of the medical men and the patients. It was the invention of a gentleman, who has for many years exerted his great knowledge of mechanics for purposes of domestic comfort ; and who has, in the most liberal manner, devoted his wealth, his time, and his inventive genius, to



public works, useful to his native town in particular, and to mankind in general.

At this moment they were interrupted. Some visitors had arrived, and they returned to the house. When Harry went into the room he saw ladies with no bonnets on their heads, and one with artificial flowers in her hair; though not much skilled in such matters, he thought this looked as if these people were not merely morning visitors, but would stay to dinner, for which, as Lucy knew by his face, he was very sorry.

The next time they were alone together, in their mother's dressing-room, in the evening, after the company were gone, Lucy asked her brother if he had not been unhappy all day since the time they were interrupted at the stove; but Harry said, that, on the contrary, he had been very happy; and that he had heard several entertaining things.

“At first,” said he, “when I saw that woman, with the artificial flowers in her head, I thought it would be a *company* day, and that it was all over with us.”

“That lady was very good-natured to me,” said Lucy, “in telling me something about the artificial flower which she wore. Did you observe it?”

“Not I,” said Harry. “Yes, I believe I did see it; it was like a lilac; and I was glad it had

no smell, for I dislike the smell of lilac in a room. But what did she tell you about it."

"That she brought it from Italy. She asked me to guess of what it was made. I looked close, and I touched it, for she told me that I might. It was not paper, nor silk, nor gauze, nor cambric: I could not guess what it was, though I had an indistinct recollection of having seen something like it somewhere. It was made of the cocoons of silk-worms. In Italy, you know, they have great quantities of these—in the silk-worm's own country—and it is well to make use of them, instead of throwing them away."

"Yes," said Harry, "if there must be artificial flowers, and I suppose there must. That lady gave also an entertaining account of some travellers, who were stopped by banditti between Rome and Naples."

"Yes," said Lucy, "and of the little girl who had her mother's jewels given to her to take care of, and who concealed them in her doll's cradle, and who kept rocking the cradle and talking to her doll all the time the robbers were searching the carriage; so that they never suspected where the jewels were, and went away without finding them. I do not think I could have had courage or presence of mind to have done that. I wish I could."

"You do not know till you are tried, whether you could or not," said Harry.

"But what was I going to say? I cannot re-

collect," said Lucy. "Oh! I was going to ask whether you heard what that lady told me about straw bonnets?"

"Not I," said Harry. "I heard her beginning to say something about the price and the fineness of hats. Women's business, thought I, to which I need not listen."

"Yet it was worth hearing," said Lucy; "though it was about bonnets, gentlemen listened as well as ladies."

"I am ready to listen now," said Harry.

"In the first place, Harry, do you know what Leghorn bonnets are?"

"Yes, I believe I do. A sort of straw hats. I know the things when I see them," said Harry.

"Very well; and you must know, too, that ladies think they are much better, because dearer than others," said Lucy. "No, I mean much dearer, because better."

"Which is it? Are you sure?" said Harry, laughing.

"Quite sure," said Lucy. "They are really better; they wear much longer, and bear wetting and crumpling. They are *infinitely* better."

"You know best. I am satisfied," said Harry. "That is settled; they are dearer because they are better. Go on."

"And they must be *much* dearer than the common straw bonnets, which are made in England,

you know, because they are brought from a great distance, from Italy."

"Aye, from Leghorn, I suppose, from their name," said Harry.

"Yes, at Leghorn first, I believe, and for a long, long time, hundreds of years, I dare say, ever since such hats have been worn, people never thought of its being possible to make them anywhere but in Italy. The straw is plaited differently, and they thought that sort of straw could be got nowhere but there. In short, they never thought of looking or trying what they could do till lately. But now people have found out, first in America, I believe, then in England, and at last in Ireland—poor Ireland!—they have found a sort of grass, the straw of which will do, and they have learned how to plait it as well as they plait it in Italy. That lady showed us two bonnets, her own and her daughter's; her own she brought from Italy, and her daughter's was made in Ireland, and, as well as I could see, the Irish one was the finest of the two. And much better judges than I am, and people who looked through spectacles, and held magnifying glasses to them, said the same. Several ladies in Ireland, as she told us, have taken a great deal of pains to teach poor girls this straw manufacture. One lady, who learned how to do it herself, from some directions in a common newspaper, set to work, and tried experiments."

“Sensible woman!” said Harry.

“And good,” said Lucy, “for it was to do good. And, after a great many trials, she made a bonnet from the very beginning, with her own hands, from the first preparing the straw to the finishing; and she won the prize for this, the best that ever was made, I believe.”

“Oh! now, Lucy, do not go too far. How do you know?” said Harry.

“I tell you just what was told me, my dear; that a person who saw it, and compared it with one which had been sent from Italy, to some French princess, declared that the Irish hat was full as good as the finest of fine Leghorn hats, which cost fifty guineas. And this Irish hat was made of a very common grass, called crested dog’s-tail,\* which grows even on bad ground. Its flower-stalks are so remarkably harsh and tough, that cattle will not touch them, though they will eat the dry stalks of many other sorts of grass. But these remain all winter in the fields useless; and they are called in Irish *trawneens*. When a thing is worth nothing, the Irish say it is not worth a *trawneen*. But now trawneens are made good for something, and for a great deal too.’

“Would you know the grass if you were to see it?” said Harry.

“Yes,” said Lucy, “I know it very well, and I

\* *Cynosurus cristatus*.

will show it to you the next time we are in any field where it is."

"Do," said Harry. "I like the woman who stuck to the bonnet till she had succeeded."

"She succeeded in doing a great deal more than making one fine bonnet. That would have been no great matter, only ingenious," said Lucy; "but I will tell you much more, and much better. This kind lady taught several poor Irish girls to make these hats; and two, not older than fourteen, working in their own cottages, (cabins they called them,) made in one year twelve bonnets, and besides, they did all the work that was wanted in the house as usual. Their twelve bonnets were sold for a guinea a-piece. A great many such have been bespoke, and are to be sent over to London. The children of those poor Irish who, as you know we heard, were almost starving last winter, have now one good way, by which they may earn guineas for their fathers and mothers."

"That is good, indeed," said Harry. "I am sure that woman who made the first bonnet, and taught them all, must be glad."

"Yes, I am sure I should, if I were in her place," said Lucy. "And, Harry, mamma told me, that if I can learn to do this plaiting, I may teach it to our poor widow Wilson's daughters. To-day I saw a little bit of it, which the lady who told us all this brought in her work-bag. She

let me undo a bit of it, to see how it was done, and she gave us some straw, and we began to try."

"Now I know," said Harry, "why you were all plaiting straw so eagerly. I could not think what had seized you, when I saw you all so busy with straws when I came back from playing. But now, Lucy, to go to another thing, for we have said enough about this—did you observe the old gentleman who sat in the arm-chair by the fireside?"

"The same gentleman who, the first day at dinner, talked of Wedgwood's ware, and of vegetable pie dishes?" said Lucy. "Yes, I saw him, indeed. He took a great quantity of snuff, and I could not bear—"

"What?"

"*It.* Oh horrible, Harry!—his pocket-handkerchief—"

"I did not see it," said Harry.

"I am glad of it," said Lucy. "I do not like him."

"You do not like him! my dear. I assure you," said Harry, "he is a very sensible man; for I heard him talking to my father and Mr. Frankland about stoves, and flues, and fire-places, and hot air."

"Very likely," said Lucy; "but I wish that he had not had those two great streaks of snuff along the wrinkles of his waistcoat."

“Never mind that,” said Harry; “I want to tell you something entertaining he told me.”

“Well, do then, I would rather hear it from you than from him,” said Lucy. “I hope, Harry, you will never take snuff.”

“No, no, my dear; no danger.”

“But when you grow old, my dear, great danger. So many old people do, and young too. Now I will tell you the names of all the snuff-takers I know.”

“No, no, no! my dear Lucy,” said Harry, stopping his ears, “pray do not; but let me tell you about a little bird.”

“A little bird—oh! that is another affair—I thought you were going only to tell me about stoves. What about a little bird?”

“It was about stoves too,” said Harry; “you must hear that, before you come to the bird. Do you recollect some one said there was a disagreeable smell from a stove in the passage.”

“Yes,” said Lucy, “and the people began to debate whether it was a smell of smoke or of burnt air.”

“Then it was, that my old gentleman asked if they knew what is meant by *burnt air*, and he began and told of a doctor\* somebody, who tried some experiments to determine whether heated iron gives out anything unwholesome to air, that passes over it, or whether it takes any thing away

\* Dr. Desaguliers.



from it, so as to make it, in short, unfit for our breathing."

"So he took a bird, I suppose," said Lucy.

"Stay, stay; first he took a small cube of iron, and heated it to a great heat: I am sorry I forget the degree," said Harry.

"Never mind," said Lucy, "get on to the bird."

"And he put it into an exhausted receiver," said Harry.

"The bird?" said Lucy.

"No, my dear, the cube of iron. I wish I had never told you about the bird."

"Well, well, I will not be bird-witted," said Lucy. "Papa, you know, told me I was bird-witted once: but, Harry, I beg your pardon. Now, tell me; he took a small cube of iron, and he put it into an exhausted receiver."

"Yes," said Harry; "he placed the cube of iron so that whenever he let in air, it should all pass through a hole in the hot iron."

"You never told me of any hole in the hot iron," said Lucy.

"There I was wrong," said Harry; "I should have told you, that he had made a hole through the iron cube; then he let the air into the receiver, and it passed through and over the heated iron; and when this receiver was filled with this air, he put a little bird into it, and it breathed the air

without seeming to be in the least hurt, or showing that he felt any difference between it and fresh air."

"But the bird could not speak," said Lucy; "and we are not sure it liked it."

"Not sure, certainly," said Harry; "but now listen to the next experiment, and you will find what happened. The man made the same experiment with a cube of the same size of heated brass, and put the same bird in the same receiver, after it had been again exhausted, and filled with air which had passed through and over heated brass."

"Well," said Lucy, "and what happened?"

"The bird died," said Harry, "in a few minutes."

"Poor bird!" said Lucy. "The man was very cruel; I mean the experiment was cruel."

"No," said Harry, "because he tried the experiment for a good purpose, to save the lives and health of human creatures."

"That was good," said Lucy; "but I think he might have tried the experiment as well without killing the bird. He should have taken it out, when he saw it gasping for breath, as I am sure he did before it died. And he should have let it recover in the fresh air."

"Certainly," said Harry, "it was cruel, as you say, to kill the bird, because it was unnecessary.

But, except that mistake, was not it a good experiment ?”

She admitted that it was a good experiment ; but she observed, that the lungs of birds and of human creatures are different, and she thought it not quite a certain proof, that because a bird cannot live in such or such air, that therefore it must necessarily be unwholesome for human creatures. Her mother, to whom she appealed, thought this was true, and so did Harry.

“ How much we have had to say and think of, from what passed to day !” said Lucy. “ And how many curious facts and entertaining stories we heard in conversation, though we were so vexed at being interrupted when the visitors first came in !”

“ Yes,” said Harry, “ I thought of that ; and thought how right my father was, in telling me that we may often learn as much from conversation as from books.”

BOATING PARTY.

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A BOATING party was proposed by Mr. Frankland, on the third and last day of their visit, and Harry and Lucy were invited to be of this party, at which they much rejoiced. They had never been in any boat. This had not a sail, it was to be rowed with oars. They walked down to the side of the river, which ran through the grounds, and they found the boat in a little creek, moored to a post in the bank. Lucy thought it a little dangerous to walk over the board that was laid from the land to the edge of the boat. One of the boatmen would have taken her by the arm, but as she saw Harry walk on fearlessly, she followed without assistance. They were desired to sit down as soon as they were in the boat, and something was said about *trimming* it. How, or why, a boat was to be trimmed, Lucy could not guess, and she was curious to see what would happen. Nothing happened, but that every body sat still in their places, except one of the men who was to row, and who, sticking his oar against the ground, pushed off from the shore. Then cross-

ing over Lucy's head with his oar, and bluntly saying, "By your leave, Miss," he succeeded in getting the boat out of the little creek, in which it had been moored.

Now they were fairly out in the river, and all the boatmen began to row, excepting one, who sat at the end of the boat, watching the way it was going, and guiding it by means of the rudder or *helm*, of which he held the handle under his arm.

After they had rowed a little way, this man made one of his companions change places with another, who was much heavier; and then seeming satisfied, said, "She is well trimmed now." Lucy perceived that *she* meant the boat, and now understood that, by trimmed, he meant that the weight on each side of the boat was balanced.

All was new and amusing to Lucy; she listened to the sound of the oars, and watched the sparkling drops, hanging from their edges, as the men lifted them from the water. They raised them out of the water, not edgeways, but with the flat part, or *blade*, horizontal, as you would raise a spoonful of any liquid. The use of this, as Harry perceived, was to diminish the resistance of the air against the oars, as they were moved forward, in order to replunge them in the water.

His father told him, that this motion is called "feathering the oars."

“ Now I understand,” said Lucy, “ that verse in the song of the jolly young waterman, which you used to sing, papa : ”

“ Did you not hear of a jolly young waterman,  
Who at Blackfriars bridge us'd for to ply ?  
He feather'd his oars with such skill and dexterity,  
Winning each heart and delighting each eye.”

As they rowed along, they saw a pretty villa on the banks of the river. Lucy suddenly started up in the boat, and asked Harry if he should not like to live in that beautiful place with the gay veranda.

“ Sit still, my dear,” said her mother ; “ for if you overturn the boat, you will never live anywhere.”

Effectually quieted by this suggestion, Lucy sat down instantly, and quite still, silently enjoying the fineness of the day, and the pretty prospect of houses, gardens, parks, and woods, as they rowed on, and observing the reflection of the trees and buildings in the clear river. A bird, with white outspread wings, was skimming over the water, which Lucy wanted Harry to see ; but he, close at his father's elbow, was intent on hearing what Mr. Frankland was saying of some foreigners, who had lately been at his house, in the course of a tour they were making through England. He had taken them out boating ; and in going down this part of the river they had been par-

ticularly struck, not merely with the picturesque beauty of the scenery, but with the appearance of wealth, comfort, cheerfulness, and elegance in the residences of our English gentry. The great *territories* and *palaces*, as they called them, of our high nobility, did not surprise them so much as the vast number and variety of the lawns, and pleasure grounds, and parks of our country gentlemen. One of these foreigners was French, the other Italian. In Italy, there are fine places, and fine gardens belonging to the nobility, but none of these comfortable habitations, fit for persons in the middle ranks of life. The Frenchman said, that these country houses were amazingly different from the comfortless *chateaux* in France. They had paid visits to several of our country gentlemen, and liked their mode of living so much, that even the Frenchman protested, that if he had not had the honour of being born a Parisian, he should prefer the lot of an English country gentleman to that of any other being in the universe. The Italian was further struck by the liberty enjoyed, and the equal justice done to all, as far as he could see, in England. He found, that many of our most distinguished men have made their own fortunes, many risen by their own talents and exertions, from the lower ranks of life. He found, that in this country, though birth has great advantages,

education does more ; and industry and genius have the road to fame, and wealth, and honours, open to them ; he would, therefore, as he declared, rather have been born in England, even in a lower rank, than in the highest class in any country, where such equal laws and liberty, and such strong motives for exertion, are not to be found.

Harry understood all this, though it might seem a little above his years, and liked it the better, perhaps, on that account ; besides, he enjoyed the praises of dear Old England.

There was in the boat a sailor, who was now called upon to sing for them, as he had a good voice, and knew many sailor's songs ; and there was a boy who played on the flute. This boy was Scotch, and sang for them several pretty Scotch boat songs.

The singing was interrupted by the man at the helm calling out rather unceremoniously to the boy with the flute, bidding him have done with his *noise*, for they had something else to mind now. They were coming, as he said, fast upon the *weir* ; and the men, who had been resting upon their oars, letting the boat float with the current, while they listened to the music, now began to row *across* the stream, which was carrying them forward with increased velocity. Lucy imagined there was some danger, but what it was



she did not know, for she had never seen a weir, nor had Harry; nor if he had known, was it any time for talking. All were silent. The man who steered seemed intent on passing quickly through the current, and all hands joining in the pull, they reached and brought the boat safely into a little creek, where they moored her, by throwing a rope from her round the stump of a tree.

When they were all safely lodged on the bank, and while the boatmen were wiping their foreheads, Harry inquired if there had been any danger, and asked what was meant by the weir. Mr. Frankland said, he would show it to him soon, but they could not see it from the place where they were standing. They walked on a little way on the shore, and presently heard a sound, as of waters falling, but still could not see from whence the sound came. It became louder and louder, as they advanced, till, having passed the overhanging branches of a willow, which interrupted the view, they saw what caused the noise of falling waters. The stream was rushing down a step, formed by a long ridge or dam, which lay obliquely across the river. This ridge was the weir, and there might have been some danger if the boat had been carried too near it, by the force of the current.

They were now to walk on to a place, where

they were to get into another boat, on a canal. As they passed along the bank, opposite to the weir, they had a full view of it, as the waters, arching over its rounding brim, formed a length of low, white, and greenish cascade, sparkling in the sun, and by its fall indented with changing lights and shades. While Lucy watched and admired these, Harry inquired what was the use of this ridge, or weir, which he saw was not a natural step in the bed of the river, but which seemed to be built of mason-work, for some particular purpose.

Mr. Frankland directed his eyes to a mill on the bank, and told him, that the use of this weir was to dam up the river, so as to secure a constant supply of water, and to give a fall sufficient to keep the wheel of this mill in motion. Harry wished exceedingly to have a nearer view of the water-wheel and of the mill. Windmills he had seen and examined, but he had seen watermills only from the road. Mr. Frankland said, it would not take them above half an hour to walk to the mill and back again, and was willing to grant Harry's request; Mrs. Frankland did not like to refuse him, yet she seemed doubtful; she looked at her watch, fearing that they should scarcely have time; she said, that she was anxious to be home in good time for dinner, because she did not like to keep an old friend waiting. How-

ever, if the mill could be seen in half an hour, there would be time; she promised to wait for Harry; and his mother said that she would sit down on the stump of a tree, and make a sketch of the pretty situation of the mill, while he went to look at it. No sooner was permission granted, than Harry darted off, and was sure he should be back again in less than half an hour. But time passes quickly when we are amused, and when we are following our own particular tastes. First, the great water-wheel was to be seen, with all its buckets, and he stood observing how the water turned it. It was, as the millwright who came out to them said, an *overshot* wheel. Then it was to be explained to Harry, what is meant by an *overshot wheel*, and the difference between this and an *undershot wheel*. This was a mill for grinding corn: he had seen flour mills turned by wind, and as the construction of the mill work was, as his father told him, nearly the same in this as in those which he had seen, there was no occasion to go over it. Indeed, he would have returned directly, but that he wanted to look at a crane, which was used for lifting up the sacks of corn from out of the boats, to the granary in the upper part of the mill; and for letting down the sacks of meal, when ground. Harry thought he had been but a few minutes looking at this, and a few more minutes were spent in seeing a sack

drawn up, and five minutes more in examining the motions of a certain *bolting* or sifting machine, the operation of which, when explained by the overseer, particularly delighted him.

The overseer showed him, that though the wheat, when it had passed through the mill-stones, came out crushed or ground, yet that the finer parts were mixed with the coarse flour, as well as with the bran, or outer coat of the grain. In this state it was first spread out on a loft, in order to cool, and then it was poured down through a wooden funnel, or *hopper*, into the upper end of the bolting machine. This was a long hollow cylinder, surrounded with a sort of net work of wire, resembling gauze, but of three different degrees of fineness. It was fixed in a sloping direction, and the overseer having kindly stopped the motion of the machinery, showed Harry, that within the cylinder there was a framework of brushes attached to a small iron axis, which passed through its whole length. The overseer, by pulling a cord, set this iron axis again in motion; and Harry perceived that the flour, when rapidly whisked round by the brushes, was forced out through the meshes of the wire; the finest flour passing through the upper and closest division of the gauze; and so on, till nothing remained, but the bran which fell out at the lowest end of the cylinder. Each species of

flour was received in separate boxes, from whence they were taken away in sacks, according to the various uses to which they were to be applied. The finest flour being employed in making the whitest sort of bread, or in pastry ; the coarser in household bread, and the bran in a variety of domestic purposes.

Highly interested with what he had seen, because the patient overseer had made him comprehend it thoroughly, Harry hastened back to his mother, and was not a little astonished to find that they had been away an hour instead of half an hour.

Mrs. Frankland, however, who always hoped the best, said that they could make up for lost time, by walking quickly to the place where they were again to get into a boat.

“ Quick time ! March ! ” said Mr. Frankland, and on they marched, in as quick time as they could, till they reached the canal—a long level stripe of still water, which, as Lucy said to Harry, looked no better than a broad ditch full of water.

She saw many large boats on this canal, loaded with coals, others with goods of various sorts, and some crowded with people. To her mortification, they were to go on in one of the canal boats ; and slowly they now went, nor was there any pleasant sound of oars. Instead of

being rowed by men, this boat was drawn on by a horse, who was fastened to it by a long rope, and who, walking on a path on the bank, the *trackway* as they called it, tugged on with his head down, and as slowly as his feet could step. Lucy thought he looked quite stupified, and as if he was walking in his sleep.

“Why do people make canals, papa?” said she.

He explained to her, that canals are made to supply the want of navigable rivers: he said, that canals are extremely useful for carrying easily, and cheaply, heavy goods, and numbers of passengers.

Harry supposed, that canals could be made only through flat countries, and in ground that was quite level. But his father told him, that they can be carried through ground that is not level.

“And how do they manage,” said Harry, “when they come to hills, because water cannot go up hill; we could not, I think, go safely in a boat down hill, or down steps: you know we were obliged this morning to get out before we came to that ridge, that little step in the river, the weir.”

“Yes,” said Lucy; “one of the boatmen said, and my own sense showed me, that it would have been very dangerous to attempt it; the

boat would have pitched forward, and filled with water, and we should all have been drowned."

"Then how do people manage when they come to uneven ground?" repeated Harry. "Perhaps they do as we have done to-day, get out, and walk till they have passed over the hill, and then take to the water again."

"That was the case formerly," said his father, "and is still practised in some places; for instance, in America, and even in this country, in some of the fens of Lincolnshire, they not only are obliged to get out of their boats, Harry, and walk, but must carry their boats along with them, over land, from one place where the canal stops to another, where the ground, being nearly level, it can go on; but this is inconvenient, Harry, even to passengers, and consider what it must be where heavy loads are to be carried."

"Very inconvenient," said Harry. "Then I suppose people take great care, in the first place, to choose the most level parts of the country for their canals, and to go round the hills, instead of going over them."

"True," said his father, "but sometimes they cannot go round them: what is to be done then, Harry?"

"I see nothing that can be done, but to cut through them, as we saw one of the hills we passed over in our journey, where, from the height

of the banks, it appeared to have been cut down several feet, to let the road go through: the same must be done, I suppose, for canals, and where great stones, or rocks, come in the way, these must be blown up with gunpowder, as we saw men *blasting* away a rock, where they were making a new road. Then the rubbish, and stones, and earth, must be carried away, and a level bed left for the canal."

"*Must* is a word easily said, Harry," observed his father; "but all this digging, and blasting, and carrying away of stones and earth, is extremely tedious, and expensive; so much so, that it would be impracticable to have carried canals across parts of the country, where they now go, if it had been necessary to make the whole bottom, or bed of the canal, upon one level. The difficulty is obviated, by means of an ingenious contrivance, called a *lock*. We shall come to one on this canal soon, and then you will see how it is managed that we pass over inequalities of ground, without being obliged to get out of the boat, and without danger of its being overset."

"That is the best of it," said Lucy. "Is it quite safe, papa?"

"Quite safe, my dear: if your eyes and your ears were shut, you would not perhaps know, that you were passing through a lock"



Harry determined, however, to keep his ears and eyes well open. Presently they came to two large wooden doors, which would have stopped the way across the canal had they been shut, but they were open, and flung quite back. Their boat passed on between the doors, without their feeling any difference in the motion, or perceiving any change in their position. The doors were then closed behind them, and they found themselves in a sort of box, or reservoir, filled with water, just large enough to hold their boat without striking against the stone work on each side, or the wooden doors at each end. There were two doors, opposite to those through which they had entered; these they found shut; but a sluice or sliding door was immediately after their entrance drawn up; and this gradually let off the water that was in this basin, or reservoir, and the surface of the water gently sunk, sunk, sunk down, with the boat upon it, with an imperceptible motion. Lucy could, as she said, only know that they had moved, by seeing the height above, and observing, on the stone sides of the lock, the marks of where the water had been on their entrance. They continued thus gently sinking till they came to the level of the water in the canal at the other side of the gates, through which they were now to pass. When it came to this level, the men opened the gates, and the

boat was drawn out, and went on without difficulty on the canal. His father bid Harry look up to the part of the canal, where they had been before they entered the lock, that he might see the height from which they had sunk.

“ Now, Harry,” said he, “ tell me how it happened, that when we first came into the lock, we found the water in it upon a level with the water in the canal above, on which we had been going ?”

Harry answered, that he supposed, that before they had come up to the lock, men had opened the great gates, and had let the water from the canal rush into the reservoir till it rose to a level.

“ Not the great gates, Harry,” said his father: “ the rush of the whole body of water from the canal would be too violent. Think again.”

Harry thought again, and said he supposed there were small sluices, on the side of the lock, next the upper part of the canal, similar to those next the lower, which he had seen opened; and he supposed that these sluices had been opened, before they came up to the lock, and had gradually let the water in.

His father told him, that this was exactly what had happened, and reminded him of a whistle, which he had heard, from one of their boatmen, some time before they came to the lock,

which was the signal for the man at the sluice to open it, and get ready the water for the coming boat.

Harry was much pleased with this most ingenious contrivance. "It seemed so easy," he said, "that he thought even he might have invented it."

"This is the case with almost all good inventions," said his father.

"How nicely and gently we sunk down, down, in the boat," said Lucy, "on the level water in the lock, while it was flowing out. As my father said, I am sure, if my eyes had been shut, I should not have perceived that we were going down. What a depth we sunk! What a step that would have been, Harry! for a boat to come down: impossible, without a lock; but if you can go up and down stairs in canals—"

"Stairs! I do not know that," said Harry; "but one step, certainly."

Her father told Lucy, that he had seen, in Scotland, on the Caledonian Canal, seven or eight locks, immediately following each other; and the people of the country called these *Neptune's stairs*.

Mr. Frankland was glad to see that Harry and Lucy had been so much pleased with the lock, as it was for the purpose of showing it to them, that he had come home by the canal.

Soon after passing through the lock they landed by the side of a road, where their carriage had been appointed to meet them. Mrs. Frankland rejoiced to see it ready waiting for them, and again she looked at her watch, as if afraid they should be late.

## WINDMILLS.

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LATE they certainly were, and very late; and cross, and very cross was the old gentleman, who had been kept waiting and starving, as he said, an hour and a half beyond the regular dinner time. Mrs. Frankland bore all he said, and all he looked, with such gentleness and good humour, that Lucy wondered how he could continue angry. She thought, however, that he must be terribly hungry, and that when dinner came, and when he had satisfied his hunger, he would grow good-humoured again. No. At dinner he grew worse and worse. Every thing was wrong. The fish was overdone, and the venison was over-roasted; and some fault he found with every one of the many good things, which Mrs. Frankland, with persuasive words, recommended.

“Try this, my dear sir, or try that.”

But nothing he tried would do. Mrs. Frankland looked sorry, and still kindly soothed him; but at last he said something very provoking about ladies never being punctual, and seldom thinking of their absent friends. Harry could not bear this, and, his natural bashfulness quite

conquered by indignation, he called out in a loud voice,

“ That is very unjust ! ”

The old gentleman looked up from his plate at Harry, whose face was red all over.

“ Well done, my little turkey-cock ! ” said he, half laughing. “ What have you to say or to do with the business ? ”

“ Only that it was all my fault, ” said Harry.

He explained, and said, that he had staid too long looking at a mill, and talking about an undershot and overshot wheel.

“ Mighty well for you and your mill, ” said the old gentleman, in a tone between pleasantry and reproach ; “ but pray, young gentleman, what was that you said about, ‘ *Very unjust ?* ’ ”

“ It was unjust to say that ladies never think of their absent friends, sir, ” replied Harry ; “ because Mrs. Frankland, who is a lady, *did think* of her absent friends, and of you in particular ; for she was very anxious to get home in time, lest you should be kept waiting for dinner, which she said, sir, that you do not like. ”

“ Who does, sir ? ” said the old gentleman, now joining in a laugh. “ But since it was all your fault, I must be satisfied, and must be obliged to Mrs. Frankland for her anxiety about me. This hare is very tender, and not over-roasted, which, considering all things, is wonderful. Mrs.

Frankland, let us make up our quarrel by drinking a glass of wine together.”

Mrs. Frankland's good temper and sweet smile conquered him. His forehead unwrinkled, and he became quite good-humoured, and talked of old neighbours, and of his good old friend Mr. Wedgwood again; and of the Staffordshire canal—the *Grand Trunk*, as he called it—of which the late Mr. Wedgwood was the first proposer, and which has enriched so many individuals, who had shares in the original undertaking.

After dinner, when the ladies left the room, Harry followed them, for he did not understand what was saying, about *shares in navigation*, and the interest paid upon them. While the ladies were drinking coffee, the conversation turned upon the cross old gentleman, and bore rather hardly upon him: one lady in company declaring that she thought Mrs. Frankland had been too kind to him; that, for her part, she should not, had she been in Mrs. Frankland's place, have thought herself bound to submit to his rudeness, or to bear his ill-humour. She went on to laugh at him for his epicurism.

But Mrs. Frankland stopped her. She said, that she was much attached to this gentleman; that he was an old friend of her husband's, and of his family, and had long shown them kindness, for which she felt grateful; and that the only way

in which she could prove her gratitude was by trying to make him comfortable and happy in his declining years, which could not be done without bearing with his little foibles. His real benevolence, and excellent sense and information, made amends for them ; his pettishness was soon over, and his kindness of heart always remained.

Lucy admired and liked Mrs. Frankland for speaking in this manner. She resolved, that, when she grew up, she would be equally good-tempered, and would bear with the foibles of old friends, even if they happened to be a little cross. Above all, she resolved that she would be as steady as Mrs. Frankland, in defending them in their absence.

In the evening, after the old gentleman had taken his nap, and was sitting in his arm chair, by the fire side, he caught hold of Harry's arm, as he was passing, and said to him in a gruff, but good-natured tone—

“Tell me, little man, why you are so curious about mills? Are you to be a miller, or a millwright pray? Or what are you to be?”

Harry, who generally understood what was said to him quite literally, answered gravely, that he believed he was not to be either a millwright or a miller: that he did not yet know what he was to be; but, whatever he was to be, it could do him no harm to get all the knowledge he could. And



he wished to learn all about mills, because it entertained him.

“And what do you know about them?” said the gentleman. “Can you tell me what keeps a mill going?”

“Wind keeps a windmill going,” replied Harry, “and water a watermill. There are other kinds of mills, which are kept going by horses, and some are moved by men, and many by steam.”

“Upon my word, you know a vast deal,” said the gentleman.

“No, sir, I know very little,” said Harry, bluntly, and looking ashamed, and not well pleased.

“Well, I will not affront you any more by flattering you, since I find you do not like it,” said the old gentleman. “Come,” added he, drawing Harry towards him, “we shall be good friends yet, you will see. I saw you playing with my grandson at marbles yesterday. Do you know how marbles are made?”

“No, sir,” said Harry, taking one out of his pocket, and looking at it. “I should like to know how they are made so very round and smooth: I should think it must be difficult.”

“It is: my friend Mr. Wedgwood told me, that he had found it one of the most difficult things he had ever attempted; and when I was on the Continent I inquired how they were made.”

“ And how are they made, sir ?” said Harry.

“ First they cut a certain sort of stone into bits of any irregular shapes, no matter what, nearly the size of a common marble. These they throw into an iron mill, in which there is a number of partitions, and to each partition strong rasps are fixed, in a slanting direction: the mill is worked by water, and is turned with great swiftness: the rubbing of the stones against the rough rasps, and against each other, rounds them, and by degrees smooths and polishes them, in the same manner as the gravel becomes rounded in the bed of a river. When they are formed to the proper shape, they fall through circular holes, made in the bottom of the mill, of the right size to let them through. From Nuremberg, the town where they are made, they are brought down the river Rhine to Rotterdam, and thence sent all over Europe, to all countries and places where boys play at marbles; and where do they not? And now you know more about marbles than nine in ten of the hundreds of boys of your age, who have their pockets filled with them.”

The backgammon table was now set, for the old gentleman usually played a game with Mrs. Frankland about this time every evening; but instead of going to it, he staid talking to Harry, and telling him of various things which he had seen when he was in Holland.

“When first I went to Amsterdam,” said he, “I remember, as I approached the city counting forty-six windmills all in motion. The Dutch have long been famous millwrights, and many of the contrivances, now in common use in our mills in England, were brought from Holland; for instance, one which you may have seen in your journey here. Did you take notice, that on some windmills there is a very small sort of fan-wheel, which stands out a little from the top?”

“Yes; I know what you mean, sir,” said Harry.

“So do I,” said Lucy. “When first I saw it, I thought it was a little windmill to frighten away birds from the corn.”

“And do you now know the use of it?”

“I do,” said Harry; “for my father showed me one, and explained it to me; the use of that little wheel is to turn the great sail-wheel towards the wind, by means of the wind itself, so that whichever way it blows, the mill continues to work. In those which have not this ingenious contrivance, the mill must stand still every time the wind changes, and the miller cannot set it in motion again, without a great deal of trouble; he must haul round the whole top of the mill in an awkward way.”

“Why? how?” said Lucy. “Do Harry explain the two ways in which these different wind-

mills turn, or are turned. I have some idea but still I forget exactly how it is."

"Oh! I am sure you know," said Harry.

"Perhaps I *did* know; but go on as if I did not, begin from the beginning; first, if you please, with the awkward way, with that windmill which has no little fan-wheel."

"That common mill," said Harry, "is called a post windmill, because it is supported upon a post, which is fixed firmly at bottom, and which goes up through the middle of the inside of the wooden body, or tower-part of the mill. This tower is separate from the mason-work, and from the grinding wheels underneath; it hangs on the top of the post, and can be turned round upon it."

"This way do you mean? Like this?" said Lucy, holding her pencil upright, and hanging her thimble on its point.

"Something like it," said Harry. "But the great sail-wheel is fastened to the wooden tower, and one cannot be moved round horizontally without turning them both. Suppose the wind changes from north to south, then the tower itself must be turned, so as to bring the front of the sails to the side opposite to that on which they had stood."

"How inconvenient! And how does the miller do this? for that tower, and the sails and all, must be a great weight," said Lucy.

"He could not do it without the help of a lever."

said Harry. "There is a huge ladder, which is fastened to the upper part of the tower, and which reaches from that to the ground, sloping outwards, so as to be a prop and *stay*, to keep the mill fixed in the position in which it is to stand, with the sails facing the wind. But the wind changes, and the mill must turn. Then the miller lifts up from the ground the lower end of this great ladder, which he then uses as a long handle, or lever, by which he turns round the mill, till the sails are again properly placed."

"So much for the post windmill; now for the other," said Lucy; "that with the little fan-wheel, as you call it."

"That does the business cleverly, and without any trouble to miller or man. Only the top, not the whole body of this kind of windmill is moveable. The axis of the great sail-wheel goes through this moveable top, and can be shifted round horizontally along with it: this top rests on rollers, so that it can move easily on the top of the solid stone wall of the tower. Now for the little wheel."

"Aye, the little ingenious wheel," said Lucy.

"That is so placed, that its vanes catch the wind whenever it does not blow upon the sails of the great wheel. So as soon as *great wheel* stops, *little wheel* sets a-going, and it sets in motion a train of wheel-work, all which I need not de-

scribe to you. I need only say, that it has the power gradually to turn the moveable top round, till it brings great wheel with its sails facing the wind; then great wheel sets a-going; and little wheel by this time, having worked away from the wind, stops. Its business is done, and it rests, till it is wanted. When the wind again changes, so as to blow on its vanes, then it sets off again, and works the great wheel round to the right point, and so on continually."

"Very well, you understand it, I see," said the old gentleman, "if I may say that much without your thinking that I mean to flatter you."

Harry smiled; "but," said he, "there is a thing I do not at all understand about windmills. I saw some standing still, while others nearly in the same situation were going: I was thinking what the reason of this could be; and I suppose that there must be something different in the way in which the vanes or sails themselves are sloped, or *set*, I believe I should call it."

"You think rightly, I believe," said the old gentleman. "I have a friend in France, a scientific man, who made a windmill, which continued working when all the other windmills in the neighbourhood remained motionless. The common people used to gather round, and stare at it, and say, that it went by enchantment, for they could not conceive how it could go with less wind than

their own ; but this arose from the judicious position of the vanes, which had been placed so that the wind should act upon them with the greatest possible force."

"I wish I knew that judicious position," said Harry ; "I have often tried to discover it in making little windmills, but I could only place the sails by guess. I should like to know the rule and the reason, and the best possible way."

"And I should be very glad if I could tell you all this, my dear, but that is beyond me. Learned men have thought and written much upon this very question ; but I am not a man of science, or a mathematician, therefore I cannot explain it to you. I can describe only the things which I have seen and which I understand."

He then gave Harry an account of several things he had seen in Amsterdam. Harry knew that this city is built upon piles. Lucy said, she recollected reading the number of these piles, which was prodigious.

Harry asked, whether any of them had given way, or whether the houses stood upright upon them.

"No," said the old gentleman ; "the first idea I had when I entered Amsterdam was, that many of the houses were tumbling down, they were so much out of the perpendicular line, but still they do not fall."

Harry was going to ask the reason of this, but another question occurred to his mind, which he was afraid he should forget if he did not ask it first. "Pray, sir," said he, "do you know if the Dutch are acquainted with the use of steam-engines?"

"Oh! yes, certainly."

"Then why," said Harry, "do not they use steam instead of wind, to keep their mills at work?"

"Why should they?" said the old gentleman.

"Because," said Harry, "wind is uncertain, they cannot have it when they please; and if they have not wind, their mills must stand still. If there is a storm, they cannot make the wind less, or more, just as they want more or less force, or quickness; but we can manage steam as we please, at all times of the year, and in all weather."

"Very true, my little mechanic," said the gentleman; "the Dutch are now beginning to use steam-engines; and what is more—"

What more he said, Lucy was in no condition at this moment to hear, for on the scattering of the snuff which he threw from his fingers, she was seized with a fit of sneezing, that seemed as if it would never end. When she recovered, she heard the old gentleman speaking of the embankments, or high and broad banks, which the Dutch have been obliged to raise to protect the country from inundations. These embankments are secured



chiefly by mats, fastened down by willows, which are twisted together, and which remain after the mats decay, and thus form the best barrier against the force of the sea.

“Willows !” said she, “such yielding things, which I can bend with the least touch ; can they withstand the whole force of the sea ?”

“Yes, exactly for that reason,” said the old gentleman, “because they do not resist ; just as you may have seen the most yielding manner do best against the torrent of anger, and the gentlest of women subdue the most violent-tempered men.”

Lucy smiled ; she was always ready for a simile, but she liked this extremely, and was pleased with its particular application. Harry’s heart now opened. He drew close to the elbow of the arm chair, from which he had before kept at a certain distance, and he began to use his privilege of asking questions freely, which he had till now done only with great reserve. His mother soon called him away, and advised him and Lucy to go to bed, as they were to set off early the next morning to pursue their journey. They were sorry to go, and every body seemed sorry that they were going. The old gentleman asked which road they intended to take, and when Harry’s father answered, by Coalbrook Dale, he said that he was very glad of that, for the sake of his young friends.

“Perhaps I shall not be up when you set off

in the morning," said he, "so shake hands, young gentleman, and fare you well. It is happy for you, that so early in life you have acquired such a desire for knowledge. To-morrow you will see—"

Mr. Frankland interrupted him, "My dear sir, do not tell him *what* he will see. Leave him the pleasure of surprise."

JOURNEY RESUMED.

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“GOOD-BYE.” It was come to that melancholy word, and as Lucy put her head out of the carriage window, to say the last good-bye to Mr. and Mrs. Frankland, who were on the steps at the hall-door, shutters opened in a bedchamber above, the sash was thrown up, and the old gentleman put out his head, and repeated “Good-bye! good-bye! and a good journey to you.”

“Thank you, thank you, sir; and pray shut the window, or you will catch cold,” said Lucy. “He was very kind to you, Harry, after all,” continued she, as they drove away; “and told you a great many entertaining and useful things; and at last I liked him very well, though he did take so much snuff. And though he was a little cross yesterday at dinner, he made up for it afterwards. I do believe, Harry, that he loves Mrs. Frankland in his heart.”

“Who can help it?” said Harry.

“I wish,” said Lucy, “that when I grow up I may be such a woman.”

“I wish you may,” said Harry, in a tone that sounded gruff, because it was as much as he could do to command his voice to speak at all, he was

so sorry to part with these kind friends. Lucy indulged him in his taciturnity, and began to examine a little red morocco memorandum book, which Mrs. Frankland had put into her hand at parting, and which she had held till now unopened. On turning over the leaves of this book, she found some of the pages filled with close writing.

“Dear, good Mrs. Frankland!” exclaimed Lucy. “Look, mamma, she has written all this for us, with her own hand: and what do you think it is?”

“‘The Juvenile Gardener’s Calendar, dedicated to Harry and Lucy, by their sincere friend, E. Frankland.’

“‘Spring,’ ‘Summer,’ ‘Autumn,’ ‘Winter,’ all in four little pages,” said Lucy. “I am always puzzled with the long directions in gardening books, about heaps of things, too, which I have not; but here, I see, are only such flowers and plants as we have, or ought to have, in our gardens, Harry; and,” continued she, after looking over the calendar, “it tells me exactly, all I wanted to know, about the times and seasons for planting and transplanting, and sowing seeds, and how to have successions of pretty flowers. I must read it to you, Harry.” She read, and when she had finished, he joined in her delight, at finding that it contained all, and no more than they wanted.

“And you read it much better, Lucy, than you sometimes read writing,” said Harry.

“Because,” said Lucy, “this is much plainer than writing is *sometimes*. Do you recollect, Harry, how I stumbled in trying to read to mamma your translation?”

“Yes, I knew you wanted to read it particularly well,” said Harry, “but you *boggled* terribly: it made me very hot.”

“Not hotter than I was,” said Lucy. “I wanted to read it particularly well indeed.”

“That was the very reason you could not,” said Harry; “you were too anxious and frightened.”

“But what frightened me was, that I could not make out the writing. I knew I was making nonsense of what I was reading, and I could not help it. Since you have set up to write a running hand like papa’s, you run all your letters into one another, so that at last, in some of your words, there is not a single plain letter.”

“Ah! my dear! I can show you in that very translation several—”

“Possibly; but then you make three kinds of *r*’s, and when I have learned to know one of them, then comes the other, quite different, and all your *m*’s, and *n*’s, and *u*’s, and *v*’s, are so alike, no human creature in a hurry can tell them asunder; and you never cross your *t*’s, so how can I tell them from *l*’s.”

“But I do dot my *i*’s,” said Harry.

“Yes, you do; but you never put the dots over the right letter; I can never guess to what heads the hats belong; and then, worse than all, you half scratch out, and half write over, and half turn one letter into another, and then repent, and leave it no letter at all. But all this I could bear, if you did not make vulgar flourishes.”

“Oh! Lucy, be just; I have left off flourishing, you must acknowledge, ever since you told me it was vulgar. I have never flourished since that day.”

“But that day was only last Tuesday,” said Lucy.

“I do not know whether it was Tuesday or Wednesday,” replied Harry; “but I know it was the day you read, or could not read, my writing to mamma, and I have never flourished since.”

“Poor Harry! I beg your pardon for reading your translation so badly,” said Lucy; “the next I will read better, if I can.”

“The next I will write better, if I can,” said Harry. “Let me look again; how does Mrs. Frankland make her writing so plain?”

“And so pretty too,” said Lucy. “It looks pretty because it is so even and straight; and it is distinct, because—let me see—she always makes the same letters the same way, that is one good thing; for then I know them again when I meet with them; and she leaves a little space between

her words, so that we may see they are separate words ; and she finishes each letter, and does not make her *m*'s and *n*'s so very much alike, that people cannot tell the difference. The little *e*'s, too, are a little different from the *i*'s."

"Very little," said Harry ; "if I hide the other letters, I defy you, Mrs. Lucy, to tell even Mrs. Frankland's *i* from her *e*."

"But look at the difference, Harry ; the *e* is a little open at top ; or at worst, I know the *i* by the dot over it. Look, the hat is always on the right head, and I know the head by the hat."

"A woman's way, indeed, of knowing a head !" said Harry, laughing.

"Oh, Harry ! when you come to laughing at women," said Lucy, "I know you have nothing else to say."

"Yes, I have," replied Harry. "Since you are so fond of reading Mrs. Frankland's writing, here is a little bit more for you ; here is a page in your book, which you have not read."

Lucy took the book, but was disappointed when she saw this page was only a catalogue of the botanical names of the flowers and shrubs, mentioned in the Juvenile Gardener's Calendar. She did not know the use, she said, of calling flowers and shrubs by Latin names, when they have good-enough English names, by which all people may know them if they please. She confessed, that

the only thing she had not liked in all that Mrs. Frankland ever did or said, was her having that day, in the garden, always told the Latin names of the flowers after the English.

“Harry, I know you think as I do, that you thought so at the time; that made me dislike it the more, because I was afraid you would think it was—you know what.”

“I know,” said Harry; “and I did not like it I own.”

“We will ask mamma,” said Lucy.

They had been all this time talking to one another, on their own side of the carriage, and their father and mother, on theirs, were conversing on something perhaps as interesting to themselves. It was necessary to wait for a pause. At the first which occurred, the case was laid before them, Lucy stating it with some hesitation, and ending by saying,

“Am I wrong, father, to think it was pedantic? Am I wrong, mamma, to say anything about it?”

“Not at all wrong to speak your opinion freely to us, my dear,” said her mother.

“You would be foolish,” said her father, “if you blamed without inquiring whether you were right or wrong; but you would be wrong if you spoke to any stranger of a fault that you saw, or thought you saw, in those who had been kind to you.”



“You do not think it was pedantic, then, mamma?”

“No, my dear, I do not; but before we can understand one another, we must settle what we mean by pedantic. What do you mean?”

Lucy said she knew what she meant, but she could not exactly describe it. She turned to Harry. First, he said, that it was talking Greek or Latin in the wrong place; he added, that it was trying to show that we had any sort of learning that other people had not. But this, Lucy thought, was rather vanity or ostentation than pedantry. They had heard people call things pedantic, which they did not think were so; for instance, a boy had once said that Harry himself was a pedant, for talking of the siege of Syracuse, and of the machines used there, because the boy knew nothing about them, and disliked reading.

“Then you perceive,” said his mother, “that the meaning of the word varies with the different degrees of knowledge of those who use it, and of those who hear it. I remember when it was thought pedantic for a woman to talk of some books, which are now the subject of common conversation. Sometimes old-fashioned learning, and sometimes useless learning, is called pedantry; and it is generally thought pedantic to produce any kind of learning that is so unusual, that it is not likely that the company is acquainted with

it, or can be pleased by it. In short, pedantry may be said to be an ill-timed parade of knowledge."

"To go back to Mrs. Frankland, mamma," said Lucy: "she knew that we were not acquainted with those Latin names."

"Yes, but she did not consider you as *company*. She did not display her knowledge to excite your admiration; she used those names in speaking to you, because she thought it might be useful to you to learn them. The knowledge of the botanical names of plants is not now unusual; most people we meet with are acquainted with them."

"I did not know that," said Lucy. "And now I recollect, mamma, when Mrs. Frankland was talking of plants to the artificial-flower woman, who did not seem to know anything about the matter, she called them only by their common English names; therefore, I am sure she told the Latin names to us, because, as you say, she thought it would be of use to us. If she had wanted to be admired for her learning, she would have displayed it in company. So it is proved, Harry, that she was not pedantic, and I am very glad of it."

"But still," said Harry, who did not seem quite satisfied, "remember what mamma said, that useless learning is pedantry."

“ Then the question is, whether this be useless learning or not,” said his father.

“ That is the very bottom of the question to which I want to get,” said Harry. “ What is the use of knowing all those long Latin names, when people may know the plants they are talking of as well by their own English names?”

“ They may know them, and describe them as well, to English people, but not to foreigners,” said his father. “ Most well educated foreigners, French, Spaniards, Germans, Italians, Danes, or Swedes, understand Latin, therefore it is a sort of universal language, in which botanists, and persons of science, can make themselves understood by each other. In all books of botany the Latin is given along with the common name; and then the description of the plant to which this name refers can be applied by people in different countries. I have a friend at Paris, who could not understand what was meant by a cowslip, because in French there is no distinguishing name for cowslip; it goes under the general word for primroses, *primevere*.”

“ Yet a cowslip and a primrose are very different,” said Lucy.

“ But,” said her father, “ if this French lady had been acquainted with the botanic name, she would have known the difference the moment it was mentioned, and the deficiency in the French

vocabulary would have been rectified. I remember hearing a French lady talking to a gentleman about the beautiful *Laurier rose*; the gentleman understood French, but he happened never to have seen a laurier rose in France, therefore he could not understand what she meant. She described it, but still he mistook it for a rhododendron; at last somebody mentioned its botanic name, *Nerium oleander*, and the moment the gentleman heard this Latin name, he understood what was meant, and he knew it was the common oleander which he had often seen in English greenhouses."

Harry now understood the use of learning the Latin botanic names, and he was satisfied.

"Remember, my dear Harry," added his mother, "that I mean no more than that it is useful as a language, and as a means of acquiring knowledge."

Lucy said, that she would learn by heart all the botanic names of the common flowers in the garden calendar, which Mrs. Frankland had been so kind as to write in her pocket-book; and she begged Harry to tell her, whether many of them had any particular meaning, like those two which she had been told, *Hydrangea, the water vessel*, or *Agapanthus, the beloved flower*, because she thought she could then learn them more quickly by heart, and remember them better.

Harry said that he would, if he could, but that he would rather do it at another time. He wanted to look at a broad-wheeled wagon, which was coming down the hill. And while he watched the shape and motion of the wheels, and asked his father some questions concerning them, Lucy was pitying the poor dog, who was chained underneath the wagon, and who, as he waddled along, apparently half dragged by the neck, looked very mournful. She was told, that his use was to guard the wagon, and that his being chained to it secured his always being near it. She wished very much that the man could be persuaded to loose him; a faithful dog, she thought, would guard his master's goods without being chained. Her mother observed, that it would be useless to talk sentiment to an English wagoner. Lucy wished that she had some money, that she might give it to buy this dog from his master, and set him free. Her mother told her, that even supposing she could buy this dog, the man would get another, and this dog would not perhaps be better off, as he might not find any body to feed him, "You know, my dear Lucy, we could not take him with us. What should we do for the next dog we meet under the next wagon?"

Lucy saw the impossibility of freeing them all, and sighed. Her mother was glad to see that she had such humane feelings for animals,

but said, "there is much we must bear to see in this life, that we cannot remedy; all we can do is, to take as good care as possible of those creatures of which we have the charge."

Lucy blushed: "I will take care not to forget to give poor Dash water when I have him again, mamma. - I recollect one day—"

Here she was interrupted by Harry exclaiming, "Father! pray look out of the window this instant! Do you see that streak of black powder in the track of the wagon, papa? I saw it dribbling from a barrel. Is it not gunpowder? May I get out and look?"

He spoke as fast as he could utter the words, and his father instantly called to the wagoner, stopped the carriage, and jumped out, Harry following him. It was gunpowder. They ran after the wagoner, who either did not hear, or would not stop. When they overtook him, and showed him the gunpowder running out of the barrel, he, being a sulky fellow, was very angry with the barrel, and with the man who packed it, and with the man to whom it was going, and with every body but himself. He had no clear idea of the danger he had run, till Harry's father told him, that he had some years before known a wagon to have been blown to pieces, and men and horses killed, by just such an accident. Some gunpowder had been shaken out of a barrel in the

wagon, and had taken fire, as it is supposed, from a spark struck from a flint in the road. This communicating with the gunpowder had blown up the whole. The wagoner scarcely credited the story, till he heard the name of the hill down which the wagon had been going, and then, as Harry observed, without any further question, he believed it to be true. So it is, that ignorant people believe or disbelieve, without any reasonable grounds. They staid to see the barrel well packed, and safely stowed. Some of the passengers, who were sitting within the canvas roof of the wagon, and who had looked out and listened, now expressed much gratitude, and said they might have lost their lives but for this timely discovery of danger. The wagoner then grew warmer in his thanks, and, as he was re-packing the barrel, said in his Somersetshire tone to Harry,

“ Master, you’ve done uz a mortal good turn, I finds, and if zo be it was in my power to give you a lift any ways, I’d not be behindhand, you’d zee ; but the likes of I can do little for the likes of you gem’men.”

Harry thanked him ; he wanted nothing he said, but he was glad that he and his wagon were safe.

“ How well it was, father,” said Harry, as they walked back together to the carriage, “ that

I saw the gunpowder running out, and recollected what you had told me about the blowing up of the wagon."

"Yes," said his father, "you see how useful it is to observe what passes before your eyes, and to recollect what you know at the right time."

When Lucy heard what had passed, after rejoicing that the wagon and wagoner were safe, she regretted, that when the man offered to do Harry a good turn, he had not said a word for the dog.

"I forgot the dog," cried Harry. "Father, will you stay for me three minutes? I will run and speak for the dog."

His father smiled, and back he ran. What he said, or in what words the wagoner replied, we cannot tell, for Harry never could remember either the words he used, or those said to him; but the result was, as he informed Lucy, that the dog Lion was unchained, that the wagoner promised that Lion should have liberty to run after him by day, and that he should be chained only by night.

Lucy was proud of her brother's share of this affair, and, as was ever her custom when she was happy, she went on talking of every thing she could think of, and of all that she saw upon the road: while Harry, according to his custom, when he was well pleased with himself and particularly



happy, was quite silent. After Lucy had exhausted every thing she could say, she perceived Harry's silence.

"What are you thinking of, Harry? are you still thinking of Lion and the wagoner?" said she.

"Not I, for there is nothing more to be done about them," said Harry. "I am considering what that very bright thing can be which I see out yonder, sparkling in the sunshine."

"I see it," said Lucy, "it looks like a monstrous diamond, twinkling between the trees. What is it, papa? look at it."

Her father thought it was the reflection of light from some weathercock, or polished globe on the top of a building. As they approached nearer, they saw it was from the glass roof of a conservatory."

"Reflection of light!" said Lucy; "what do you mean, papa, by the reflection of light? and what is the difference between reflection and refraction, of which I have heard?"

Her father answered, "When the rays of light are thrown back from the surface of any polished substance on which they strike, for instance, from a polished piece of metal or of glass, they are said to be *reflected*. When the rays pass *through* any transparent body, and, in doing so, are turned from their direct course, they are said to be

*refracted*, and this light is called *refracted* light."

"Do you recollect, Lucy," said Harry, "yesterday in the boat, you observed that the oar in the water looked as if it was broken? That was because you saw it through the water. Mr. Frankland told you that was the effect of refraction."

"I remember," said Lucy, "that he told me so, and that I did not understand at the time what he meant. I was ashamed to ask him more about it, and afterwards I forgot it; but you, Harry, can explain it to me, cannot you?"

"Indeed I cannot," said Harry.

"But, papa, will you be so good as to make us understand it?"

"My dear, I cannot be so good as to make you understand it yet, till you have more knowledge: I am glad, however, Lucy, that you observed the appearance of the oar in the water, and that you wish to know the reason of what you saw. Seemingly slight observations of this sort lead to important discoveries."

"Do they, indeed, papa," said Lucy.

"Yes; but often observations such as these, though they might lead to great discoveries, if pursued, remain hundreds of years useless, because people do not try to find out the reason of what they have seen. As long ago as the time of

Aristotle, which is above two thousand years, among other questions in his works on natural history, he asks, why a stick appears bent when it is held obliquely in water? This question was never rightly answered, till about four hundred years afterwards by Ptolemy. The fame of several great philosophers, among the moderns, rests upon their discoveries of the rules or laws for measuring that refraction of light, on which the appearance of the bent stick in water depends. And not till the time of our great Newton, was the whole satisfactorily explained, or all the knowledge obtained, to which it has led. He, by pursuing this and other seemingly slight observations, and by trying experiments carefully, to find out the cause of what he had observed, made his great discoveries of those properties and laws of light, which we call the laws of reflection and refraction. Even from considering the colours on a soap bubble, which many others had observed before him, but of which they had made no use, he was led to some of the most important conclusions respecting vision and colours."

But here all philosophical conversation ceased, interrupted by the sound of the horn of a mail coach. Harry and Lucy quickly darted their heads out of the window; for though oftentimes seen, Lucy never willingly missed the passing of a coach, stage or mail. This was, as Harry

guessed, the royal mail, with its guard behind, the scarlet man with the gold-laced hat, blowing the authoritative trumpet to clear the road. Proud as a king on his throne, sat the many-caped, many-cravatted coachman on his box, with his four fine horses even in hand, who kept on in full trot, regardless of the load behind—the whip idle in the master's hand, except that once he flung out the long lash with a light touch, to remind one careless horse, that he must draw fairly, and to bring him into true trotting time. As they passed, Lucy admired the horses much, but the harness more.

“ Nice!” said she, “ and nicer than any gentleman's harness. Bright brass rings standing upon the horses' foreheads, with twinkling gimmals glittering in the sun.”

Regardless of the harness and the twinkling gimmals, Harry had eyes only for the horses.

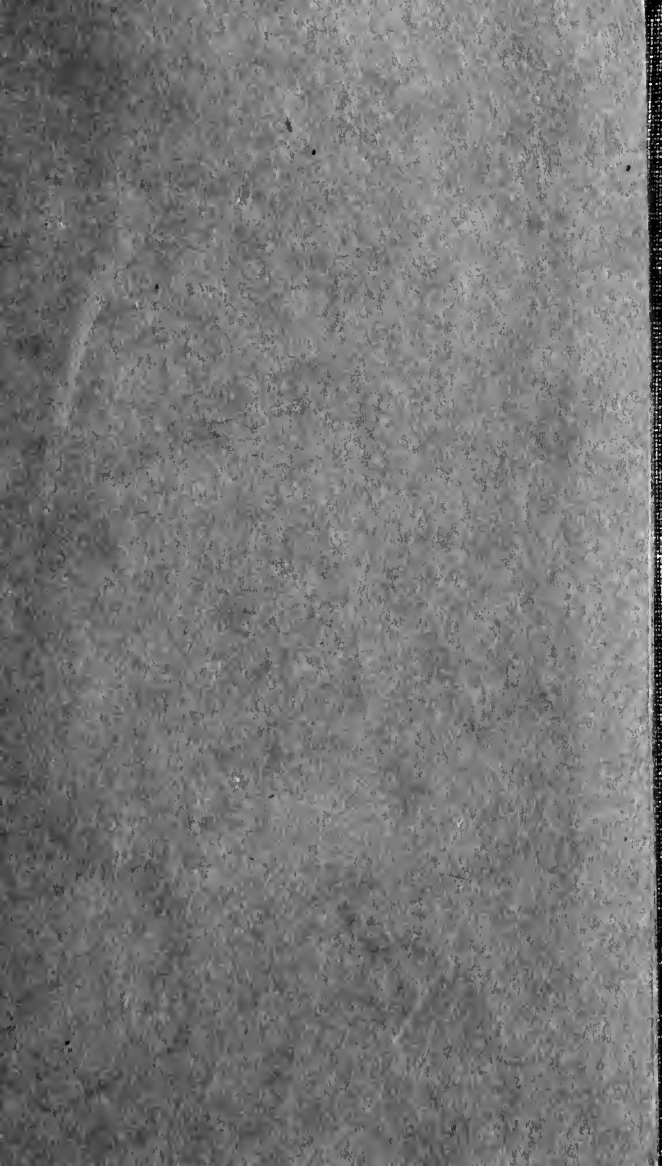
“ What fine creatures! and how they go! Oh, father! look! how they turn the corner,” cried Harry, leaning out of the carriage, to watch them till they were quite out of sight.

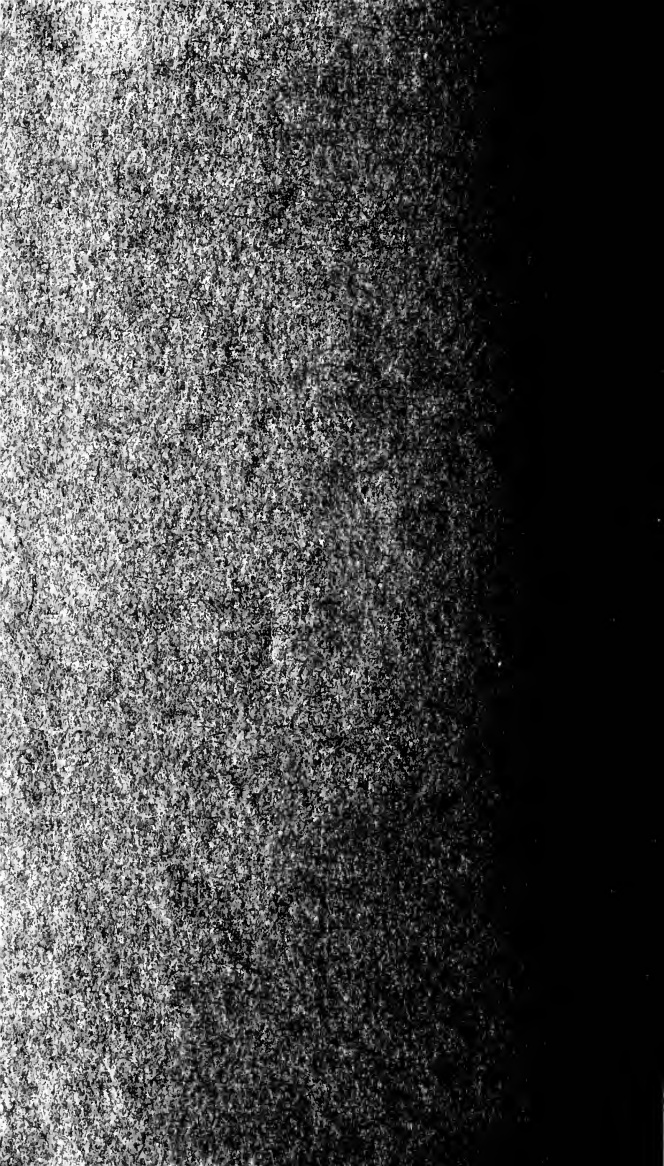
The road for the rest of this stage was, as Lucy observed, a stupid straight line: she could find nothing to do, but to count the carriages they met, in the last five miles. Her father told her, that on the Bath road he had once met eleven stage coaches in five miles. But on this road,

she met, in five miles, only one heavy laden wagon, and twelve coal carts. Harry wondered that she continued still looking out of the window, when there was nothing to be seen but coal-carts: she said, she had a reason for this, and he left her to take her own time to tell it, which did not happen this stage.

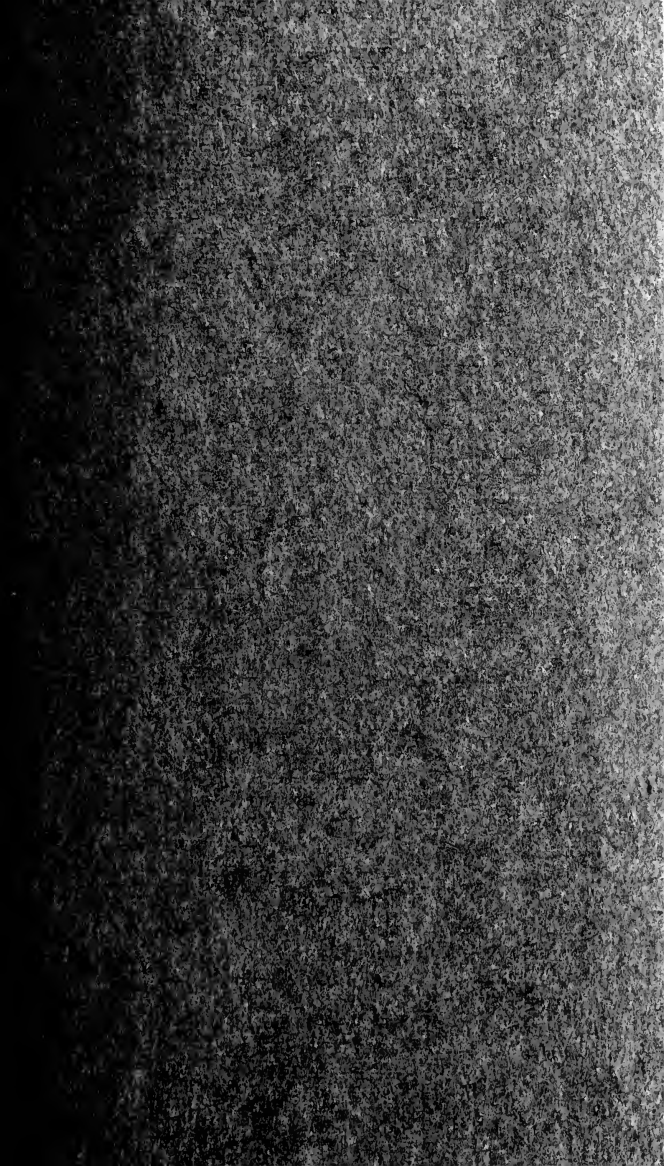
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